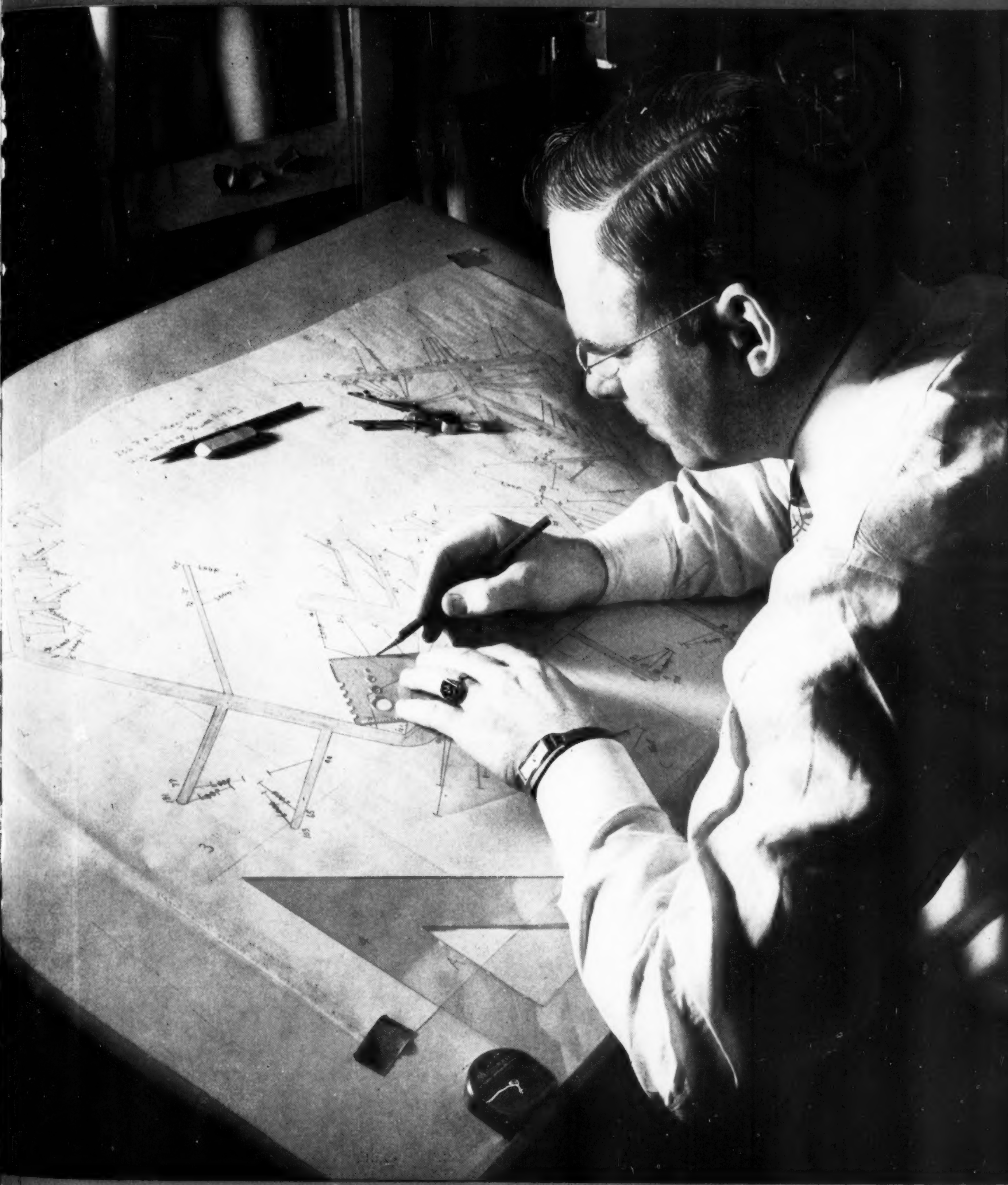
OCTOBER, 1946

RADIO

MANUFACTURING
AND
BROADCASTING

The Journal for Radio & Electronic Engineers



Design • Production • Operation

RADIO

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CONTENTS

COVER

Preliminary paper work in designing a cable harness. It is worked up from a schematic, showing the lengths of the wires and the layout of the cable. Each line must be the exact length of the wire it represents.
—*Courtesy Cambridge Thermionic Corp.*

ARTICLES

MISCELLANEOUS

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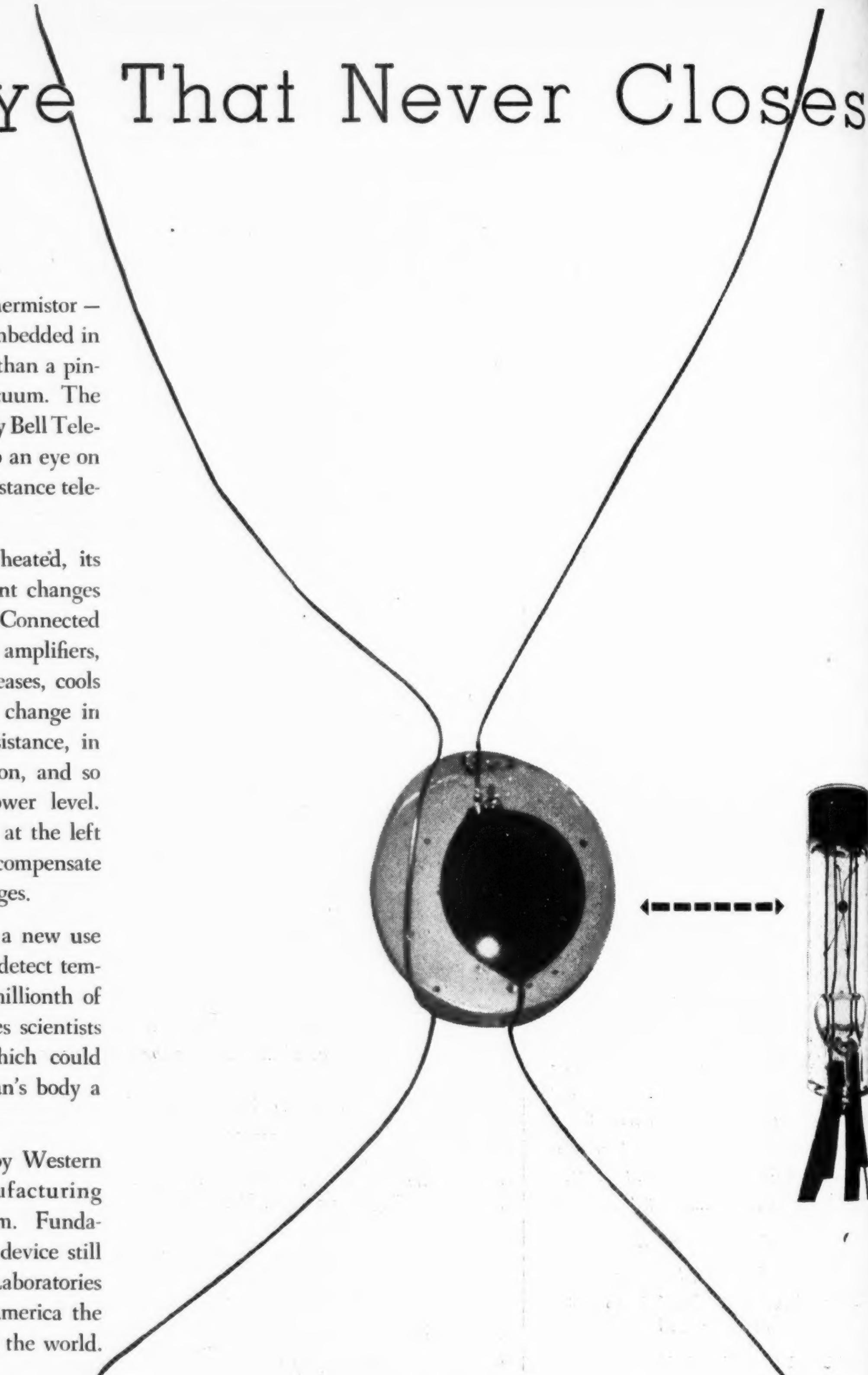


Transients

UNFINISHED BUSINESS

★ Despite soaring production figures, the quantity of radio receivers reaching the market is still far less than the potential capacity of the industry. Thousands of sets lie incomplete in manufacturers' warehouses, awaiting the time when one or more vital components become available before they can be finished. Unlike automobiles, radios cannot be shipped and sold when only partly assembled, and the accumulating stock of unfinished sets is now one of the major problems facing the industry.

In many instances some manufacturers have a surplus of some components needed by others to complete their receivers. It would be a great help all around if some sort of exchange basis could be worked out whereby a manufacturer who is long on one item and short of another could swap his surplus with someone else who needs it and who can supply items the other requires. A mounting pile of partly assembled receivers eats up capital and eventually constitutes a threat to the price structure for similar receivers. Should missing components suddenly become available to all, the resulting flood of sets would inevitably drive prices down.

For the good of the industry as a whole, manufacturers should work out some sort of co-operative plan to help each other through this period of shortages. Otherwise all will suffer. Should any manufacturers desire to list with us items they need to complete receivers, as well as those of which they have a surplus, we shall be glad to do what we can to help.

CRYSTALS FOR PUSH-BUTTON TUNERS

★ The greatest problem confronting most manufacturers of quartz crystals has been to find new ways of utilizing their enormously increased production facilities developed during the war. Because improved techniques have lowered costs in quantity production, applications of crystal control are now being considered which were formerly limited to low-production, high-unit-cost apparatus.

One such application is in push-button tuning of broadcast receivers. While crystal tuning of receivers has been used for many years, it was formerly employed solely on special purpose equipment, such as aircraft, marine, and other apparatus in limited production. Now, however, at least two of the larger manufacturers of broadcast receivers are planning to go into mass production of sets employing crystal control of the frequencies used for push-button selection. Obviously, this method will have advantages over former systems, provided costs can be held to a reasonable figure. Less servicing will be required and more precise tuning will result.

To keep costs down, it would be well for all manufacturers contemplating using this system to get together and decide on a standard intermediate frequency so that the stock of crystals required to produce the intermediate frequency will be kept to a minimum. Otherwise, the wide variety of crystals needed to cover all frequencies in the broadcast band may create inventory problems for the manufacturer and the radio serviceman. Experience has shown that new developments which are difficult or expensive for the serviceman to handle stand little chance of wide acceptance.

An article on this push-button tuning system is now in preparation and will be presented in an early issue.

IMPROVING CIRCUIT ANALYSIS

★ The resistance-coupled amplifier is so well-known that it would seem that nothing new could be said on the subject. But the methods of calculating the performance of such amplifiers have been in use for such a long time that they are sadly in need of overhauling. Now that resistance-coupled amplifiers (or resistance-capacity coupled, if you prefer) are used in a great many applications other than as purely audio amplifiers, the need for a simpler method of attacking their design has arisen.

In his article in this issue, the Dutch writer, J. Roorda, Jr., presents an improved method of solving the design problems associated with such amplifiers. Because it is simpler, yet more rigorous, we believe this should supersede former ways of analyzing such circuits. Undoubtedly there are many other circuits in common use whose analysis might be simplified if given the same critical attention. So much stress has been laid on circuit applications that methods of analyzing performance seem to have been neglected. Although present methods are usable, we are going to need a lot of fresh designing in the radio industry in the next few years, and now is none too soon to look around for simpler and better ways of meeting these design problems.

CUTTING ASSEMBLY COSTS

★ With every manufacturer faced with a labor shortage and mounting costs, it appears to be a good time to give consideration to improved methods of assembling and wiring receivers. Many schemes have been evolved during pre-war years, but for one reason or another, little has been done to get them into production. Except for the idea of printing the wiring on a photo-sensitive silver emulsion, which has very limited application, no radically new methods seem to have been given serious consideration.

One scheme which has always appealed to us is that of using an insulating material for the chassis, and flowing molten metal in grooves to make the necessary circuit connections. And there are many others. Next year, when costs merit even more careful study, undoubtedly some new production ideas will come into wide use. They should be tried experimentally now.

J. H. P.

TECHNICANA

MULTI-CHANNEL F-M TRANSMITTER

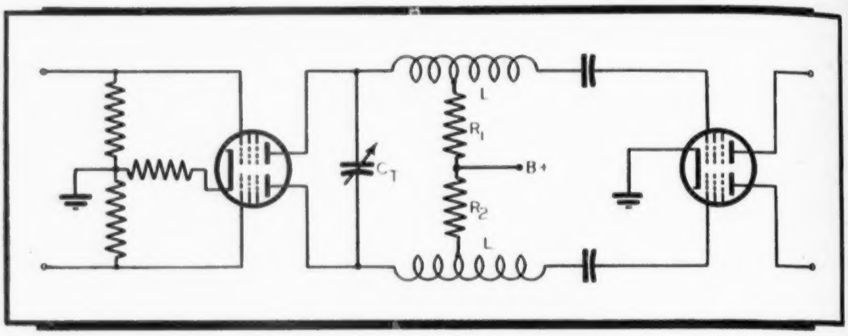
★ Interesting features of an experimental u-h-f f-m transmitter used for multi-channel telephony in Holland are described by A. van Weel in the *Philips* (Eindhoven) *Technical Review* for April 1946. The transmitter was developed for an experimental 90.5-cm link, working with a 99-cm link in the opposite direction.

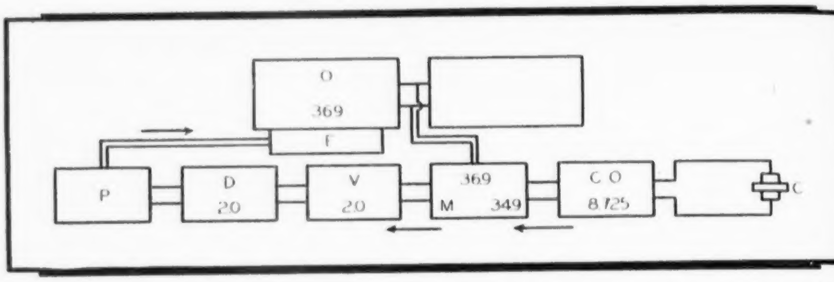
Modulation is effected with initial carriers from 12 to 204 kc to accommodate 48 telephone channels, which in turn modulate a 36.9-mc oscillator, followed by three push-pull triplers. Frequency deviation is 67 kc maximum at the oscillator. The 48 frequency bands of approximately 3000 cps width are modulated on carriers lying 4000 cps apart, using single-sideband modulation. Thus the circuits must pass the total band ranging up to 200 kc.

The best signal-noise ratio would be obtained with a maximum deviation of ten times the highest modulating frequency, and a sideband at least 1.5 times greater must be transmitted to minimize distortion. Since this requires a 6-mc pass band for transmitter and receiver, the maximum deviation was reduced to three times the highest modulation frequency to make circuit design less difficult.

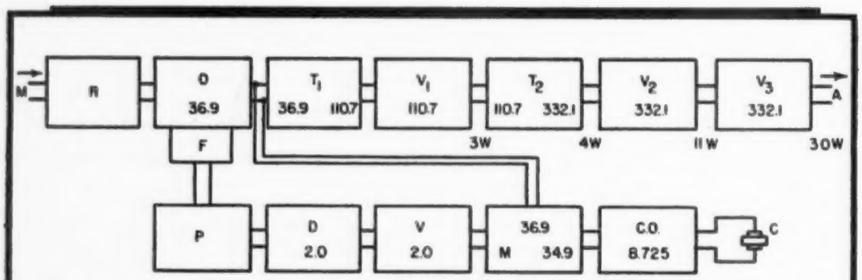
Modulating voltage is applied at *M* in *Fig. 1* to conventional reactance tubes which frequency-modulate the 36.9-mc oscillator; T_1 and T_2 are push-pull triplers with unconventional coupling circuits described below. V_1, V_2, and V_3 are amplifier stages, with antenna output at *A*. The lower block sequence is concerned with the center-frequency stabilization system, discussed below.

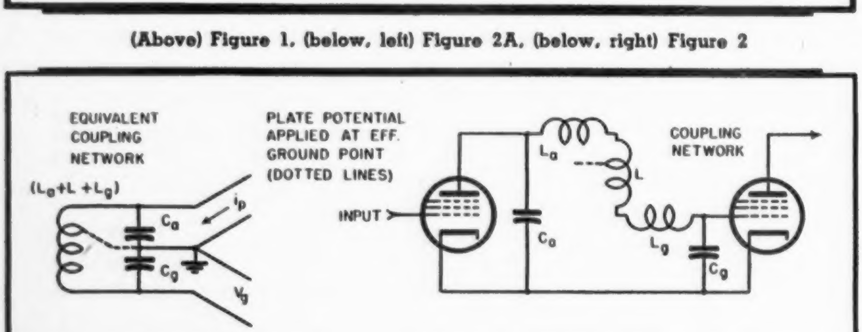
Coupling between successive stages is accomplished with the basic system shown in *Fig. 2*. C_a and C_g represent the inter-electrode capacitances, while L_a and L_g are the distributed inductance of the leads; a lumped inductance of suitable value is inserted at *L*. The resulting equivalent circuit is shown at *Fig. 2A*. In effect, the various impedances form a tapped tank circuit with a capacitance voltage-divider. Current from the driver energizes the circuit at C_a, as indicated by i_p, while the grid voltage for the output stage is developed across C_g as indicated by V_g. Since the common connection of C_a and C_g is at ground potential, an effective ground point may likewise be located on *L*, as shown by the dotted line. This is the point used to apply plate supply voltage.





(Above) Figure 3, (below) Figure 4





(Above) Figure 1, (below, left) Figure 2A, (below, right) Figure 2

Push-pull triplers were selected because common couplings throughout the circuits are minimized, as well as the filtering of the power supply. The resulting tripler circuit appears as shown in *Fig. 3*. C_T is a small tuning capacitor, while R_1 and R_2 are small resistances used to reduce r-f flow in the power supply leads as a result of any small r-f unbalance at the feed-points on *L-L*.

The center-frequency stabilization system is shown in *Fig. 4*. *C* is an 8.725-mc quartz crystal; output of the crystal oscillator *CO* is applied to a mixer *M* in which the fourth harmonic of this frequency (34.9 mc) is mixed with the average center frequency of oscillator O (36.9 mc). The mixer is followed by a 2.0-mc amplifier which energizes a conventional discriminator. The unbalance voltage from the discriminator is amplified by a pentode at *P*, which delivers its output current to an inductor *F* with a ferro-magnetic core. The inductor is magnetically coupled to the oscillator circuit, and controls its frequency by

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TECHNICANA

[*from page* 4]

the reactance component of its reflected impedance.

Should the average center frequency of the 36.9-mc oscillator drift from its nominal value, the current through the non-linear inductor F varies, causing its reflected reactance in the oscillator circuit to vary correspondingly and bring the oscillator frequency back to its nominal value.

FUN WITH FILTERS

★ A 'new filter theorem' is suggested by T. H. Turney, in *The Electrician* for April 26. The article, entitled "The Filter Theorem" is from a forthcoming book, "Electric Filters," published by Pitman.

"In order to construct a filter which will have all the above (classical properties), all that is necessary is to collect any number of any sizes of inductances and capacitances, and connect them up in any way and put four terminals anywhere, and one has produced a filter section. If one wants more than one section, others similar to the one made up can be constructed and connected end to end.

"What is the good of the theorem? (a) It is a contribution to one's knowledge of the subject. (b) It saves one thinking he may waste his time if he does research on fresh circuits. (c) Any teacher in college can make a filter for a pound or two without extensive knowledge of the subject, and demonstrate it with an oscillator and oscillo-scope."

The writer promises a proof of the theorem in his book.

SERIES RESONANT CRYSTAL OSCILLATORS

★ Circuits for oscillators which use the series-resonant frequency of a quartz crystal, rather than the parallel-resonant frequency, are discussed by F. Butler in *Wireless Engineer* for June 1946. The article concludes with suggested filters which make use of the series-resonant frequency.

The oscillator circuit frequency is found to be slightly influenced by the external series reactance of the circuit,

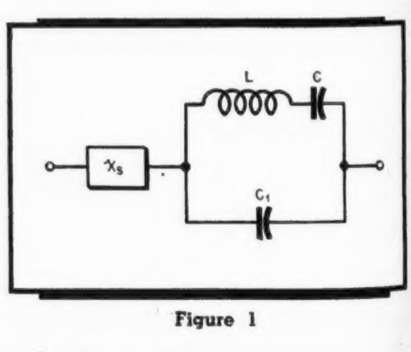


Figure 1

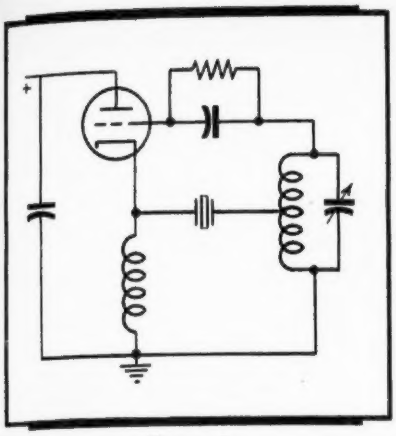


Figure 2

in contrast with oscillators using parallel crystal resonance in which case the frequency is affected by reactances in parallel with the crystal.

An equivalent circuit of a piezoelectric crystal is shown in *Fig. 1,* where L = effective inductance of the crystal, C = effective capacitance of crystal, C_1 = holder capacitance, and X_s = series reactance (air-gap action, stray inductance, or inserted reactance). The parallel resonant frequency of this circuit is given by

$$\omega^2 = (1/C + 1/C_1)1/L$$

and the condition of series resonance is that

$$(j\omega L + 1/j\omega C) = (-X_s/j\omega C_1) / (X_s + 1/j\omega C_1)$$

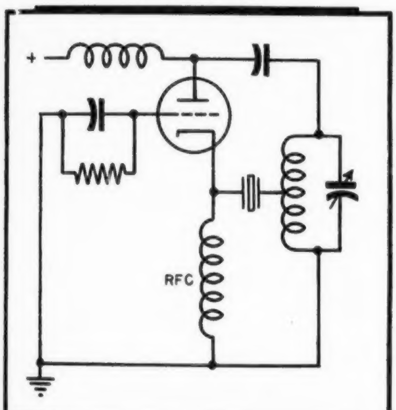


Figure 3

In the event that X_s is inductive, $X_s = j\omega L_1$, and the equation becomes

$$(\omega L - 1/\omega C) = (L_1/C_1)/(\omega L_1 - 1/\omega C_1)$$

whence it appears that the true resonant frequency of the crystal is realized only when $L_1 = 0$, or if the inductive reactance is resonated with suitable series capacitance.

In the case that X_s is a capacitive reactance, $1/j\omega C_2$, then

$$(\omega L - 1/\omega C) = 1/[\omega(C_1 + C_2)]$$

indicating that the crystal series resonant frequency is approached as the external capacitance is increased.

Practical series-resonant oscillator circuits are given by the author in *Figs. 2, 3,* and *4.* At series resonance, the crystal appears as a low resistance, permitting oscillation to take place. At other frequencies, a high reactance appears between the load and the low-impedance source, causing attenuation and phase shift with cessation of oscillation. The circuits are suitable for use with low-frequency crystals of poor quality, and will operate with crystals which refuse to oscillate in other circuits.

Figure 2 is a grounded-plate Hartley oscillator, while *Fig. 3* illustrates the grounded-grid version. The circuit shown in *Fig. 4* is a grounded-plate oscillator with feedback to the cathode circuit; this circuit is adapted for use with precision crystals designed to have one electrode grounded.

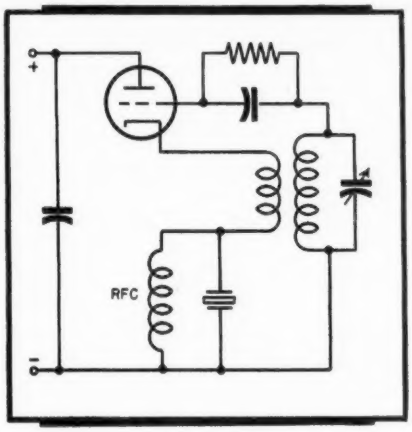


Figure 4

At higher frequencies, C_1 (see *Fig. 1*) shunts the crystal reactance and allows oscillations to occur at other than crystal frequency. Neutralization is a convenient means of correcting the circuit, as shown in *Fig. 5.* A neutralizing capacitor is coupled to the main tuned circuit by a coil having the same number of turns as between the crystal tap and ground. When $C_X = C_1$ broad-band neutralization is effected.

A feature of all these circuits is that when using leak and capacitor bias, the optimum operating condition is at minimum plate current, in contrast with conventional crystal circuits which produce instability in this region.

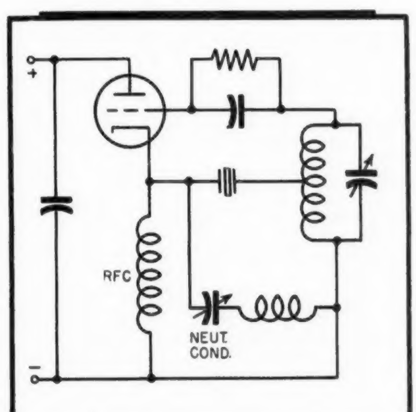


Figure 5

High Efficiency Modulating Method

JOHN BECKWITH

Phase-modulated voltages developed in an R-C bridge are combined with the unmodulated carrier in the output stage for high-efficiency amplitude modulation

There are quite a number of ways of producing amplitude modulation of a radio-frequency carrier, but few which accomplish it at high efficiency. Chireix[1], Dome[2], Doherty[3], and others have developed systems whereby an amplitude-modulated signal can be obtained without using relatively inefficient class B linear amplifiers. In most of these systems, modulation takes place between the oscillator and the last stage of r-f amplification, usually at the input to the last stage. This stage comprises at least two tubes (four for push-pull) and a number of reactances which are very critical in adjustment. There is also the problem of different bias voltages, and sometimes different plate supply voltages[4]. Some systems specify two antennas[5]. One method[6] requires five large tubes and several phase-shifting networks to produce a high-efficiency final stage. Some of these systems use low efficiency class B amplifiers, while others use class B together with class C.

The purpose of this article is to explain the functioning of a transmitter which approaches the ideal. Phase modulation of a portion of the carrier takes place immediately after the master oscillator. This is converted to amplitude modulation in the output circuit of the final class C amplifier.

Class C amplification, at full efficiency, is used throughout, without employing critical circuits. While the modulator is reactive, its design is simple and it cannot get out of adjustment. The overall system approaches the efficiency of a telegraph transmitter, making possible a high-power broadcast transmitter without a costly high-power modulator and associated power supply.

The Modulator

The modulator is essentially an electronic phase shifter. Modulation is accomplished by shifting the phase of the carrier frequency at an audio-frequency rate and combining this phase-shifted component with the unmodulated carrier frequency to produce a resultant varying in amplitude as the phase is shifted.

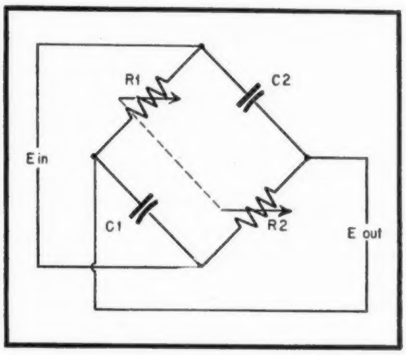


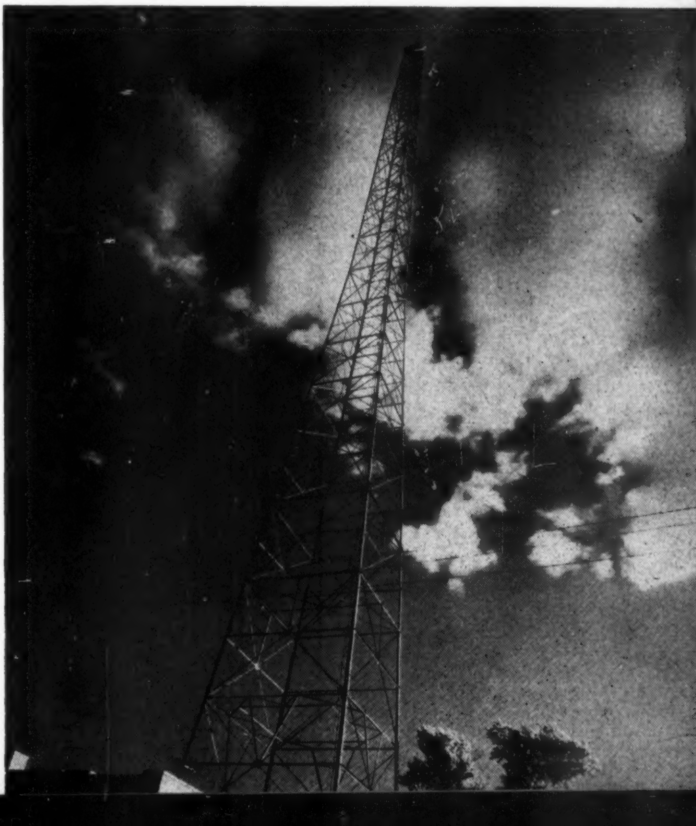
Fig. 1. Equivalent circuit of phase-shift bridge to obtain FM vector for combination with unmodified vector voltage.

To obtain phase modulation, a bridge consisting of two resistances and two capacitors is used, as shown in *Fig. 1.* In this circuit, R_1 and R_2 are equal, as are C_1 and C_2. The r-f carrier is applied at E_{in} and the phase-modulated voltage appears at E_{out}. R_1 and R_2 are high-transconductance triodes. When an audio signal is applied to their control grids, the plate resistance changes in accordance with the signal voltage. Over the positive half-cycle of the applied audio signal, the resistances of R_1 and R_2 are low in comparison with the reactances of C_1 and C_2 at the carrier frequency. For all practical purposes, R_1 and R_2 will have zero r-f resistance. Thus the output voltage will be in phase with the input voltage.

During the negative half of the audio cycle, the resistances of R_1 and R_2 will become practically infinite in comparison with the reactances of C_1 and C_2 at the r-f carrier frequency, corresponding to a phase displacement of 180°. When $R_1 = R_2 = X_{c1} = X_{c2}$, there is a phase shift of 90° (refer to *Fig. 2*). When the vectors are in phase, the voltage is doubled at E_{out}, and when the vectors are 180° out of phase, the voltage is zero at E_{out}.

The locus of operation is a semicircle as shown in *Fig. 2,* and the output voltage is seen always to equal the input voltage in magnitude, although shifted in phase. The result of these relations is to make it possible to obtain 100% amplitude modulation by combining the phase-shifted vector voltage with an equal unshifted vector voltage. This is done at a relatively high level,

This 335-foot steel tower located on the New Jersey banks of the Hudson River will soon carry Station WMGM's new Western Electric "Clover-leaf" FM broadcast antenna—the first in the N. Y. area.



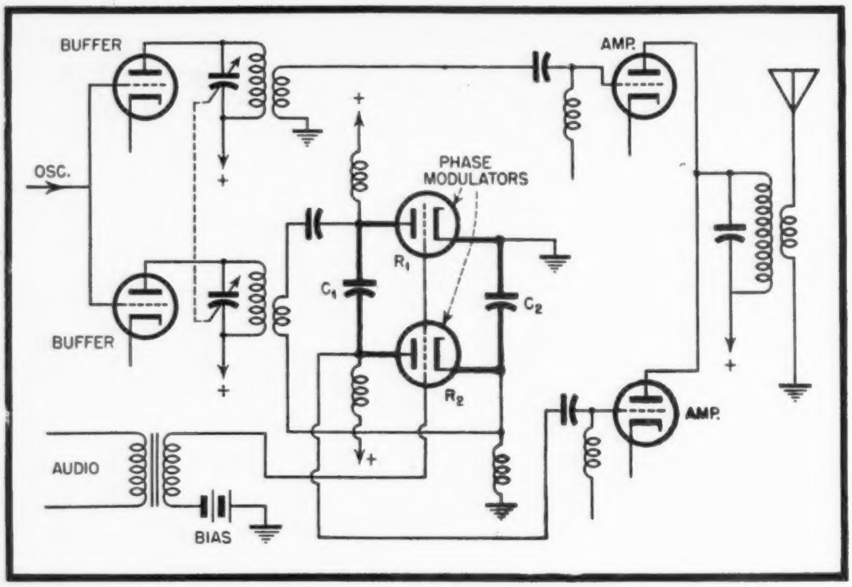


Fig. 3. Combination of vector voltages takes place at high level as shown in this basic schematic diagram.

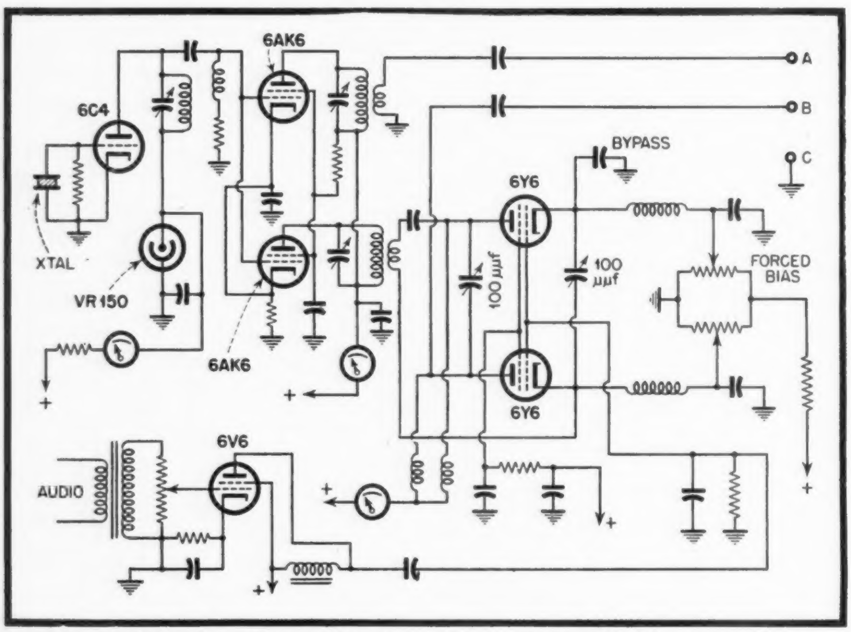


Fig. 7. Schematic diagram showing modulator section of 4.5-kw transmitter.

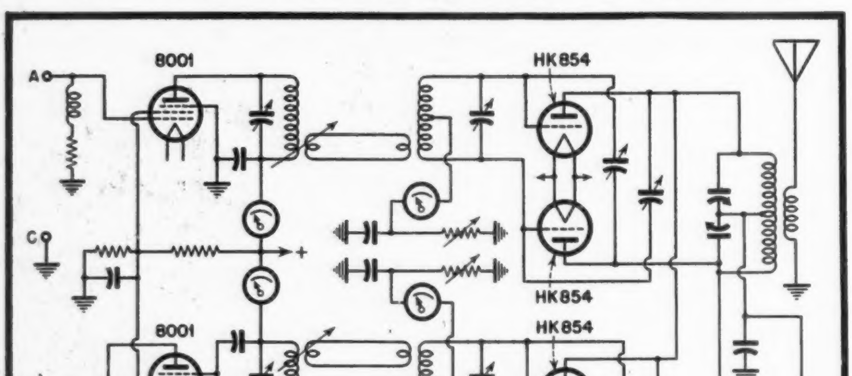


Fig. 8. Driver and final amplifier circuit for 4.5-kw transmitter.

as shown in *Fig. 3*. The results of phase shift shown in *Fig. 2* are presented in developed form in *Fig. 4* for shifts of 0°, 120°, and 180°. The resultant magnitude of the two voltages is non-linear, being proportional not to the magnitude of the phase shift, but to the cosine of half the phase shift, as shown in *Fig. 5*.

Referring to *Fig. 4*, *A* represents the voltage at the plate of the class C amplifier of the unmodulated channel. Plate voltage of the phase-modulated channel is shown at *B*, for zero modulation and assuming an operating phase displacement of 120°. This is the value used in the experimental modulators which have been constructed. The phase-modulated voltage at maximum displacement, or 180°, is shown at *C*.

Maximum modulation, or a phase displacement of zero, is diagrammed at *D*. The waves shown at *B*, *C*, and *D* are voltages which are encountered in the modulation channel. At the junction point where combination takes place, the voltages from both channels will add vectorially, producing resultants shown at *E* for 180° phase shift, at *F* for 120° shift and at *G* for 0° shift.

E_u is the unmodulated component, while E_m is the modulated component, and E_r is the resultant voltage. With reference to the diagram at *F*, E_r is the same amplitude as E_u, with the latter voltages having combined to form E_r. In diagram *E*, E_u is seen to be zero when E_u and E_m are opposite in phase. Diagram *G* shows the resultant voltage E_r as twice the amplitude of E_u or E_m, which is equivalent to four times power at the 100% modulation peak when E_u is in phase with E_m.

Comparison of these waveforms with the vector diagrams shown in *Figs. 2* and *5* will make it clear that the output waveform represents an amplitude-modulated wave. A study of the circuit relationships shows that this amplitude modulation is not entirely linear for the simplified situations discussed above. Achievement of linearity is a separate consideration which receives attention at a later point in this paper.

Referring to *Fig. 3*, the output of one buffer feeds directly to one of the class C amplifiers. The second buffer applies the r-f signal to the modulators. The modulator output feeds the phase-modulated r-f signal to the other class C amplifier tube. The phase-modulated component is then combined with the unmodulated wave in the plate circuits of the class C amplifiers, as shown in *Figs. 2* and *4*. This addition is vectorial and has been previously developed by several persons, among them Plebanski[6] and Price[7].

Because the modulation is not linear, the output might be expected to be equally non-linear. This is not actually

the case because the plate resistance of the tubes in the bridge is also non-linear, but in a direction which tends to straighten the modulation characteristic. When greater linearity, and hence greater fidelity is desired, the audio signal input to the modulator is kept below the limiting grid swing. If the modulator drive is reduced to one-half, the phase shift is reduced accordingly, but this phase shift can again be caused to vary between 0° and 180° if the frequency of each channel is doubled before recombination. That is, the phase shift is doubled when the frequency is doubled. Thus, the linearity of the system may be increased in general by diminishing the phase shift of the modulator and applying it to a sub-multiple of the carrier frequency. *Fig. 2* shows the relations of *Fig. 5* in graphical form.

Class C Used

If the phase-modulated r-f current is not recombined with the unmodulated r-f current following the r-f amplifiers shown in *Fig. 3*, but brought instead to individual tanks and further amplified before recombination, this amplification may be carried out in class C. This is because *there is no change in amplitude of the r-f voltage* (see *Fig. 4*) until after recombination, as shown in *Fig. 6*. Use of class C amplifiers following modulation results in a highly efficient and economical transmitter because of the high plate efficiency obtainable.

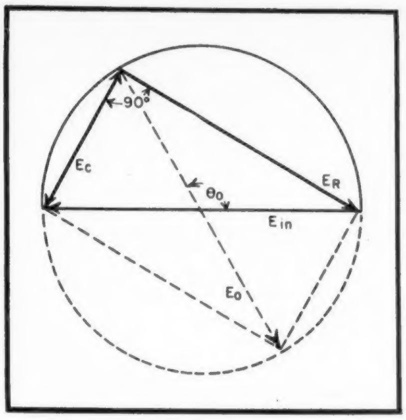
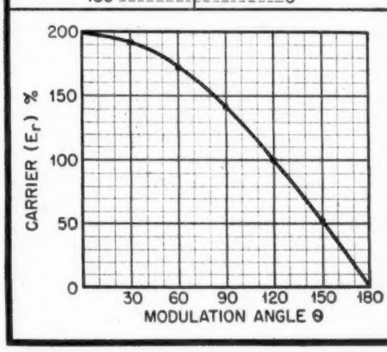
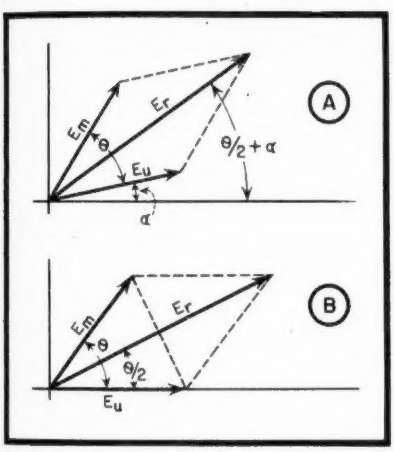


Fig. 2. (above) Circle diagram for modulator bridge. Fig. 6. (below) Resultant output voltage vs. modulation angle shown in Fig. 5

$E_r = 2E_u \cos \theta/2$

θ	E_r
0°	200
30°	193.2
60°	173.2
90°	141.4
120°	100
150°	51.76
180°	0





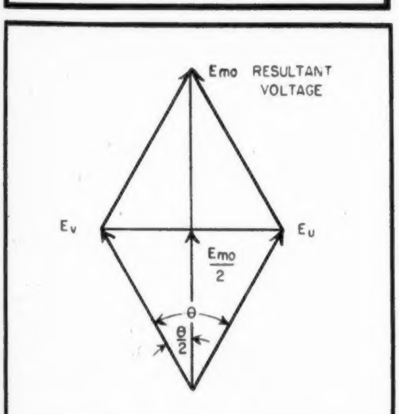


Fig. 5a. Resultant output voltage, with carrier at consant phase displacement; 5b, constant phase displacement of zero; 5c (bottom) vectors appearing in equation of text.

Complete schematics for a 4.5-kw transmitter using small, inexpensive tubes, with only two stages of r-f amplification following the modulator, are shown in *Figs. 7* and *8*. It will be understood that the outputs of the last two tubes may be connected separately to higher-power tubes rated at 10 kw or more. These may be used to drive a 100-kw amplifier.

An experimental 4.5-kw transmitter built by the author consists of a crystal oscillator feeding two pentode buffer amplifiers, one for the modulated channel and one for the unmodulated channel; the modulator shown in *Fig. 3* appears in the *Fig. 7* schematic, plus the a-f tubes. Plate supply potentials for the various stages of *Fig. 7* should be regulated.

Following the modulator are two medium-power pentode amplifiers shown in *Fig. 8* which drive the final amplifier comprising a pair of tubes in push-pull for each channel. The push-pull amplifiers deliver their outputs to the utilization circuit in parallel. Coupling between stages is adjustable to compensate for unequal amplification in the two channels, and excitation to the stages should be equalized.

The cost of a phone transmitter using this system of modulation is comparable to the cost of a telegraph transmitter, on the basis of peak modulated output. This system of modulation can be easily adapted in most cases to existing transmitters using class B r-f amplifiers to provide twice the former output for a change-over price of less than 10%.

These figures compare favorably with the following: if it is desired to triple the output of a transmitter by class B r-f amplifiers, or by use of high-level modulation, the resulting cost of installation would rise at least 100%. Less massive equipment can be built for higher output with the new system of modulation, and will require fewer operating personnel.

For amateur radio, the circuit has great possibilities because of its reduced price and high output without use of complicated circuits.

Phase-Modulation Sidebands

Since phase modulation is used, these sidebands appear in the radiated wave as well as the a-m sidebands. However, these are not greater in magnitude and spread than specified by FCC regulations, and hence are not a matter of concern.

[*Continued on page 32*]

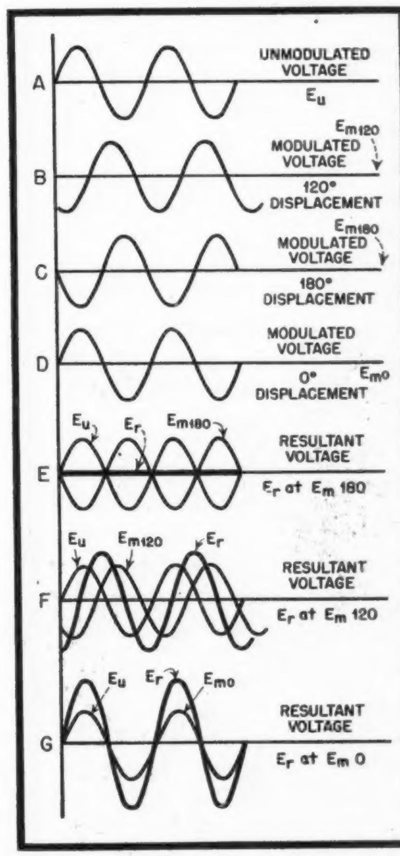


Fig. 4. Developed waveforms for three modulation conditions corresponding to phase shifts of 0°, 120°, and 180° obtained by combining unmodulated voltage with phase shifted voltage.

Notes on the Design of

SQUELCH CIRCUITS

FREDERICK DELANOY

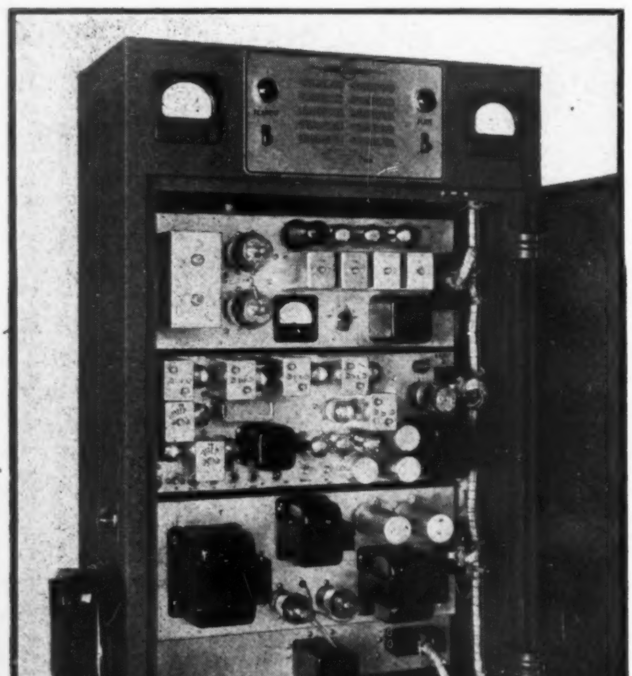
This month the author devotes particular attention to noise suppression circuits for FM receivers

WIDE-BAND RESPONSE of f-m receivers, while contributing to high fidelity of reproduction, nevertheless increases the noise level encountered between channels. For this reason, squelch circuits are of particular interest to the f-m receiver engineer. These vary greatly in design, ranging from the electro-mechanical units described last month, to blocked-audio circuits of various designs, reflected-impedance squelch circuits, and squelch oscillators as described in this issue.

Numerous subdivisions of circuits include those suitable for a-c/d-c receivers, circuits requiring switching, and those which make use of threshold controls. Some units require only one tube, others utilize several tubes to accomplish their purpose. At least one commercial method combines limiting and squelch action in one tube. This latter circuit, developed by the Admiral Corporation, is illustrated in *Fig. 1*.

Squelch-Limiter Operation

Its operation has been explained by the inventor, Ernest R. Pfaff, as follows: Signals from the i-f tube are fed to the tuned transformer, and also to the grid of another amplifier shown as a triode section of a dual-purpose tube.



Typical f-m transmitter-receiver for specialized service, with squelch circuit in receivers.

—*Courtesy Fred M. Link, Inc.*

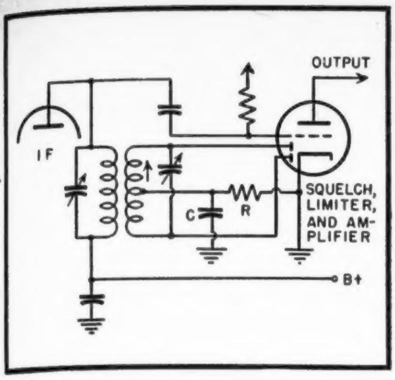
Limiting and squelch action takes place in the duo-diode section. Signals transferred inductively from the primary to the secondary are rectified by the full-wave rectifier circuit, causing a biasing voltage to be developed across the RC branch. This biasing voltage is applied to the plates of the duo-diode, reducing current flow through the diode sections.

During the time of current flow, the secondary is effectively short-circuited, and because of tight coupling between primary and secondary, the primary is likewise effectively short-circuited. Therefore, while the diodes are conducting, no signals are obtained at the triode output. This circuit provides both limiting and squelch action.

Amplitude-modulated peaks are limited or clipped to a level determined by the steady signal strength from the i-f strip, and by the value of the resistor *R*. When no signal is present, there is no drop across *R* (except for a small value due to contact potential), and any incoming signal voltage peak above this value will be rectified. Random noise impulses, being of very short duration, become completely rectified and do not appear at the output. The time constant *RC* is considerably greater than the duration of such impulses, so the impulse is over before the voltage drop across *R* has appreciably increased. Because noise is intermittent in character as compared with an incoming f-m carrier, the circuit serves as a squelching device.

When a carrier is present, the bias across *R* varies with the signal strength. To keep the signal input constant during fading, it is advisable to use avc ahead of the limiter-squelch circuit.

If an adjustable positive bias is applied to the cathode of the limiter-squelch tube, limiting action may be adjusted manually for any desired pro-



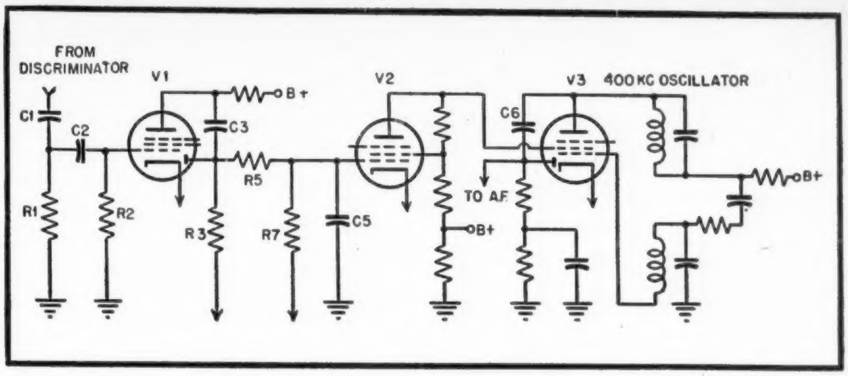
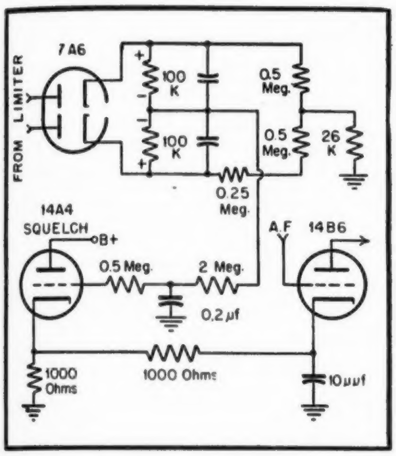
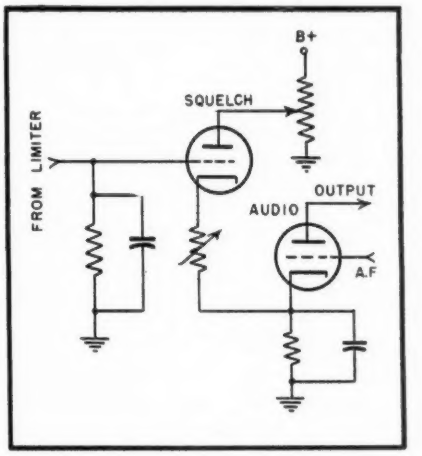


Fig. 1. (left) Combined limiter and squelch circuit for f-m receiver designed around principle of reflected impedance. Fig. 2. (right) Squelch oscillator V3 develops voltage controlled by discriminator output. Oscillator voltage is rectified and applied as squelch bias to the audio amplifier.





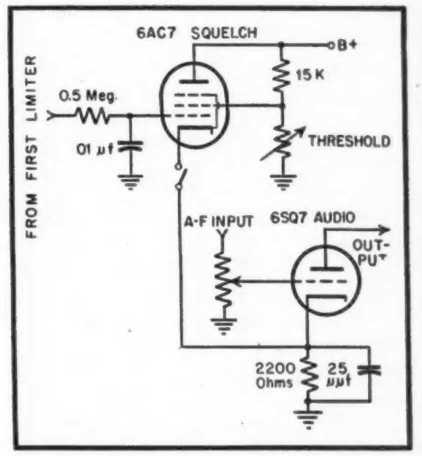


Fig. 3. (left) Schematic for typical a-c/d-c squelch circuit. Muting is incomplete, because of limited plate supply voltage. Fig. 4. (center) Two methods of controlling threshold in the cathode-coupled squelch circuit. Fig. 5. (right) Disabling switch is frequently provided in squelch circuits which do not cut off with sufficient rapidity to avoid threshold distortion.

portion of cut-off. However, the squelch action is destroyed by fixed bias. Without avc, the output will vary in the same manner as with self-bias. This is not entirely a disadvantage; limiting action is then obtained on weak, as well as strong, signals. With conventional limiters, weak signals may not be clipped, so amplitude modulation is mixed with the output. With this particular circuit, no amplitude modulation is passed, regardless of signal level.

Oscillator Squelch

Another interesting f-m squelch circuit makes use of a local oscillator, the output of which is rectified and utilized as a squelch bias. The circuit is shown in *Fig. 2*.

This circuit uses two dual-purpose tubes. V_1 is a combination noise-amplifier and rectifier. V_2 is a d-c amplifier, and V_3 is a combination squelch oscillator and rectifier. In reception of frequency-modulated signals, the limiter clips the peaks of the waves to effectively suppress noise impulses, because their a-m components are pronounced. The noise "rides on top of the signal."

However, when no carrier is present, conventional limiters fail to operate at the comparatively low noise-voltage level, and the output of the discriminator contains noise impulses which are passed along to the a-f amplifier. This of course leads to objectionable inter-channel noise in the speaker output. With the circuit of *Fig. 2*, amplitude-modulated noise impulses are applied to the control grid of V_1. Capacitors C_1 and C_2, in conjunction with resistors R_1 and R_2, form a high-pass filter. The filter passes only high-frequency noise impulses, and blocks the lower audio frequencies.

These high-frequency noise impulses are amplified and coupled through C_3 to the diode section of V_1, where they become rectified. The rectifier output polarity is negative, being taken from the plate side of the rectifier. In the presence of a carrier, V_2 receives no negative bias. V_2 is connected as a d-c amplifier, and has its grid driven directly through R_5.

Because the output of the rectifier consists of a succession of negative impulses, C_5 is placed in shunt with the grid of V_2 to smooth the negative bias supplied to V_2. Along with the negative voltage applied to the grid of V_2, a constant positive bias is supplied through R_7 which is adjusted to cause a high plate current in V_2 with no noise signals coming through. Correspondingly, the plate voltage of V_2 is low, which makes the screen of V_3 sufficiently low that the oscillatory circuit fails to function.

With noise signals present, the grid bias on V_2 increases negatively, causing the plate voltage to rise as well as the screen of V_3, and the circuit breaks into oscillation.

The r-f output from the oscillator is coupled through C_6 to the diode section of V_3, and diode current derived from oscillator voltage is utilized to develop a negative bias for cutting off the a-f amplifier.

A-C/D-C Squelch Circuit

Because of the low plate potential available in an a-c/d-c receiver, squelch circuit problems are particularly severe. In general, it is not possible to suppress completely inter-channel noise with conventional circuits, but the noise level may be reduced to a point at which it is not objectionable. A commercial circuit which has proven effective is shown in *Fig. 3*.

Operation of the circuit involves biasing the cathode of the 14B6 tube as nearly to cut-off as possible. However, the squelch characteristic is of the "soft," or incomplete type, because of low plate-supply potential. In the presence of a carrier, the 14A4 becomes

biased to cut-off and does not draw current, reducing the drop across the cathode circuit of the 14B6 and bringing it out of cut-off. In the absence of a carrier, the bias on the squech tube falls and causes a heavy flow of plate current, driving the 14B6 to the vicinity of cut-off and attenuating the noise in the a-f output to an acceptable level.

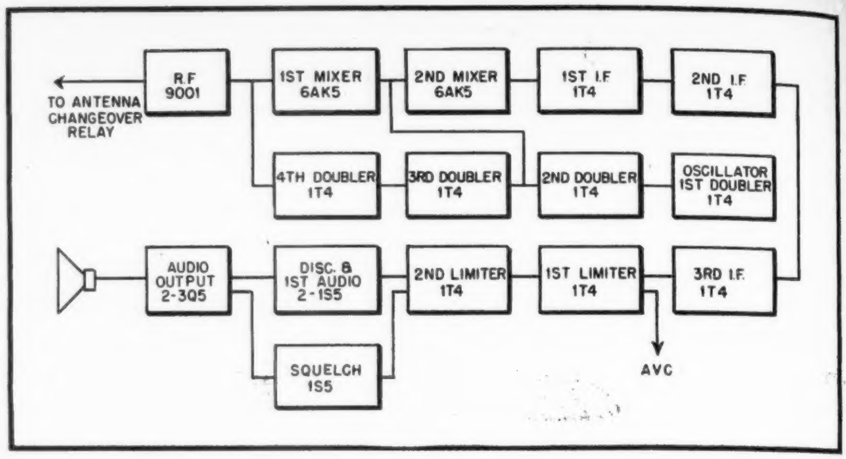


Fig. 7. Block diagram for Comco receiver unit of taxicab radio shown in Fig. 6.

Threshold and Switch Controls

Not all squelch circuits provide a rapid cut-off. Because of this characteristic, severe audio distortion will be encountered in the output with signal levels which partially actuate the squelch tube, but do not completely suppress reception. Two methods are available for meeting this situation: one design makes use of an adjustable threshold control, while another merely provides a switch for disabling the squelch tube. The unit shown in *Fig. 6* has an auxiliary pilot lamp which is energized by the squelch circuit when the signal level is sufficiently high.

Noise-Operated Squelch

The squelch circuit is (see *Fig. 7*) of the noise-operated electro-mechanical type. In the absence of a signal, the limiters are saturated by set noise and considerable a-f noise voltages are developed in the plate circuit of the 2nd limiter tube. This noise voltage is coupled through a high pass filter to the grid of the 1S5 squelch tube. This filter removes the low frequency audio components below 12,000 cycles, preventing the possibility of carrier modulation tripping the squelch. After amplification by the pentode section of the 1S5 squelch tube, the noise voltage is applied to the 1S5 diode. The negative voltage developed across the diode load resistor is used to bias the pushpull 3Q5 a-f tubes nearly to cut-off.

When a signal is received of sufficient strength to override the noise level, the noise voltage from the second limiter disappears. Thus the cut-off bias is removed and the 3Q5 tubes are restored to normal bias and operation. Positive squelch operation is further obtained by means of a relay in the plate and screen supply circuit of the 3Q5 tubes which operates when the bias is applied from the squelch circuit. In the squelched condition, the relay is open and the relay contacts short the speaker voice coil circuit to ground. Upon receiving a signal, the relay is closed, and in addition to removing the ground from the voice coil circuit, it closes the circuit to the red indicator lamp on the control panel.

On single channel operation, the squelch circuit is so adjusted that a sharp whistle in the microphone causes the red lamp to flicker, thus giving the driver a means of checking both transmitter and receiver circuits for correct operating conditions.

In addition, the receiver is so designed that adjustment of the transmitter frequency may be made using the readings of the receiver discriminator circuit which has previously been checked against the headquarters transmitter. This eliminates the need for any frequency checking equipment except at headquarters, unless crossband operation is used.

Typical methods of controlling the threshold of a cathode-coupled squelch circuit are shown in *Fig. 4*. These are equally effective when suitable control ranges are provided. In application, either the plate or cathode control is employed, but not both. The threshold control enables the operator to increase the sensitivity of the receiver when necessary, without losing the advantages of squelch action entirely.

A squelch disabling switch for a commercial cathode-coupled squelch circuit is shown in *Fig. 5*, which also has an auxiliary threshold control. The voltage across the 2200-ohm cathode resistor is approximately eight times cut-off in the absence of a carrier. The 6SQ7 operates normally with -2 volts on the grid, and circuit relations are such that with -5 volts the 6AC7 will cut off and restore the -2 volts operating bias to the 6SQ7.

However, for intermediate values of carrier level, it is possible for the 6SQ7 to be biased between the operating and cut-off points, with resulting high distortion. Opening the squelch switch effectively cuts off the 6AC7 and the 6SQ7 operates normally, under all conditions of carrier level.

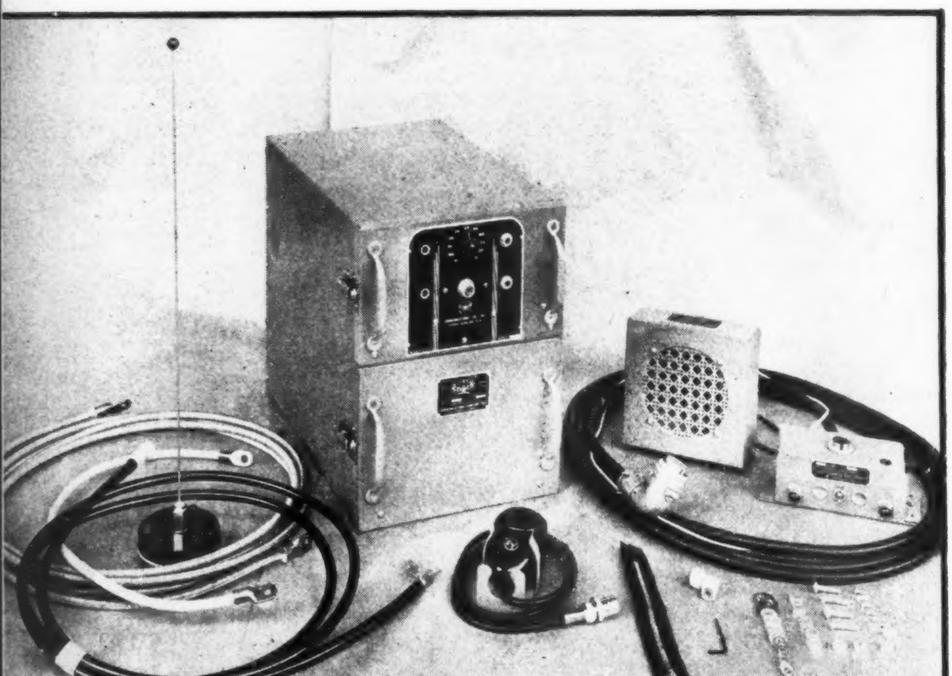


Fig. 6. Package VHF transmitter-receiver for taxicab installation, uses squelch-operated pilot lamp.

Improved Analysis of the R-C Amplifier

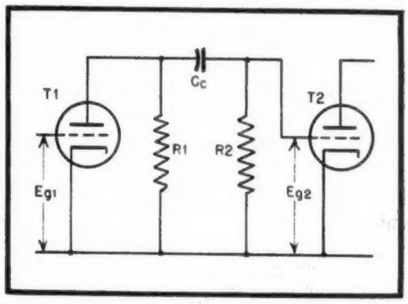
J. ROORDA, Jr.

The author presents in this important article a new and simple method of designing resistance-coupled amplifier circuits for any frequency range

IT IS CUSTOMARY to design R-C amplifiers with the aid of three equivalent circuits, each of which involves certain approximations that may be justified over a portion of the frequency response range. This device, while workable, does not entirely satisfy the analytical mind. It would be preferable to evolve a rigorous solution without approximations, in addition to determining a simple equivalent circuit which holds true at all frequencies.

These considerations have led to new design formulas which are derived in this paper, and which afford a simplified method of computing R-C amplifier performance.

A schematic diagram of an R-C amplifier is shown in *Fig. 1*, drawn in conventional form. The plate load of T_1 consists of R_1 plus the coupling network C_c and R_2. It is required to choose R_1–C_c–R_2 in such manner that E_{g2} shall be maximum over the required frequency-response range of the amplifier. Voltage amplification of the circuit is defined as the ratio E_{g2}/E_{g1}.



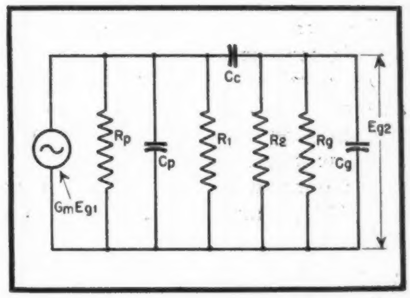


Fig. 1. (left) Conventional R-C amplifier circuit. Fig. 2. (right) Constant-current generator form of Fig. 1. wih interelectrode and stray capacitances included.

Equivalent Circuit

Solution of the circuit requires at the outset that C_p and C_g, the plate-cathode capacitance and grid-cathode capacitance be taken into account. These capacitances will include the inevitable stray capacitances of wiring and circuit components. Thus the circuit of *Fig. 2* is derived, which includes for convenience of analysis a constant-current source G_mE_{g1}. Resistance R_g is the resistive component of the input impedance presented by T_2, while C_g includes the capacitive component of this input impedance. These are to be evaluated in the conventional manner.

Circuit parameters to the left of C_c are lumped together and termed Z_p in the re-drawn circuit of *Fig. 3*, while the parameters to the right of C_c are termed Z_g. The elements of these lumped parameters are, by inspection:

$$1/Z_p = 1/R_p + 1/R_1 + j\omega C_p \qquad (1)$$
$$1/Z_g = 1/R_g + 1/R_2 + j\omega C_g \qquad (2)$$

where ω is the angular velocity of the impressed a.c.

E_p, the a-c voltage developed across Z_p, is calculated:

$$E_p = G_mE_{g1}/[1/Z_p + 1/(Z_g + 1/j\omega C_c)] \qquad (3)$$

and the ratio of E_{g2} to E_p is found:

$$E_{g2}/E_p = Z_g/(Z_g + 1/j\omega C_c) \qquad (4)$$

Gain

By eliminating E_p from (3) and (4), the amplification is derived:

$$\underline{A} = E_{g2}/E_{g1} = G_m/[1/Z_p + 1/Z_g + 1/Z_pZ_g \times 1/j\omega C_c] \qquad (5)$$

in which the underscored A signifies that this factor is vectorial.

Manipulation of (5) leads to separation of resistive and reactive components:

$$1/Z_p + 1/Z_g + 1/Z_pZ_g \times 1/j\omega C_c = (1/R_p + 1/R_1)(1 + C_g/C_c) + (1/R_g + 1/R_2)(1 + C_p/C_c) + (1/j\omega C_c)(1/R_p + 1/R_1)(1/R_g + 1/R_2) + j\omega(C_p + C_g + C_pC_g/C_c) \qquad (6)$$

whence (5) assumes the form:

$$\underline{A} = G_m/(1/R + 1/j\omega L + j\omega C) \qquad (7)$$

in which R, L, and C are evaluated from (6):

$$1/R = (1/R_p + 1/R_1)(1 + C_g/C_c) + (1/R_g + 1/R_2)(1 + C_p/C_c) \qquad (8)$$
$$L = C_c/(1/R_p + 1/R_1)(1/R_g + 1/R_2) \qquad (9)$$
$$C = C_p + C_g + C_pC_g/C_c \qquad (10)$$

Final Equivalent Circuit

It follows from (7) that the equivalent circuit of *Fig. 2* can be redrawn as shown in *Fig. 4*, with values of R, L, and C as specified by (8), (9), and (10). As no approximations are involved in equations (7) to (10), the equivalent circuit of *Fig. 4* represents unrestrictedly the properties of the R-C amplifier, within the framework of linear analysis.

It is observed from *Fig. 4* that there is only one frequency at which the amplifier network is purely resistive. This frequency f_0 (angular velocity $\omega_0 = 2\pi f_0$) is defined as:

$$\omega_0^2LC - 1 = 0 \qquad (11)$$

The amplification of the circuit is maximum at f_0, and may be evaluated:

$$A_0 = G_mR \qquad (12)$$

by substituting (11) into (7).

Analysis of Equivalent Circuit

It is found from inspection of (8) that, firstly, the largest value that R may attain is that of R_p and R_g connected in parallel (which occurs when R_1, R_2 and C_c may be considered infinite), and hence the maximum obtainable amplification is determined by the values of R_p and R_g.

Secondly, values of R_1 and R_2 should be made high with respect to R_p and R_g to obtain maximum amplification.

Thirdly, the capacitance of C_c should be as large as possible for maximum amplification. The phrase "as large as possible" is subject of course to practical limitations, and this point is considered later in greater detail.

Voltage amplification at an arbitrary angular velocity ω may be evaluated from (7) in terms of the vector magnitude:

$$\underline{A} = A_0/[1 + R^2(1/\omega L - \omega C)^2]^{1/2} \qquad (13)$$

from which it is observed that the amplification off resonance is always less than maximum.

A further interesting observation may be made: terming ω_1 and ω_2 the angular velocities at the limits of the frequency range under consideration, (ω_1 being the lower limit) and assuming that the voltage amplification at the limiting frequencies is the same percentage of the maximum amplification, it follows from (13) that:

$$(1/\omega_1L - \omega_1C)^2 = (1/\omega_2L - \omega_2C)^2$$

and since $\omega_1 < \omega_0$ and $\omega_2 > \omega_0$, we may write:

$$1/\omega_1L - \omega_1C = -(1/\omega_2L - \omega_2C)$$

from which it follows that:

$$\omega_1 \times \omega_2 = 1/LC = \omega_0^2 \qquad (14)$$

It is observed therefore that the resonant frequency of the circuit, at which point amplification occurs, is the geometric mean of the limiting frequencies. If the voltage amplification at the limiting frequencies may drop to a value pA_0 where $(p < 1)$, it may be found from (13) that:

$$pR(1/\omega_1L - \omega_1C) = (1 - p^2)^{1/2}$$

and when (14) is introduced.

$$1 - \omega_1/\omega_2 = \omega_1L(1 - p^2)^{1/2}/Rp \qquad (15)$$

Equations (14) and (15) may be used in conjunction with (8), (9), and (10) to calculate exactly the performance of an R-C amplifier. The resonant frequency and maximum amplification are determined, and various pairs of ω_1 and ω_2 are next chosen in accordance with (14), computing values of p from (15).

Design Procedure

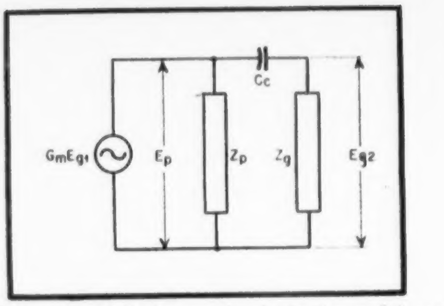
With the aid of the foregoing equations, it is readily possible to design an R-C amplifier to meet a specified set of conditions. Given G_m, R_p, R_g, C_g, and p at the limiting frequencies f_1 and f_2, it is next desired to determine R_1, R_2 and C_c. Only two equations, (14) and (15), are available for calculating the three variables. We are therefore free to choose one of these variables, in order to determine the resulting values of the two remaining variables. This may be done in such manner as to considerably facilitate the computation.

It is possible, for example, to assume C_c sufficiently large that C_g/C_c and C_p/C_c can be neglected with respect to unity, and that C_pC_g/C_c is vanishingly small with respect to C_p+C_g. Thus $C = C_p+C_g$ for practical purposes. Values of L and R are then computed from (14) and (15).

A suitable value of R_2 is next chosen, and R_1 calculated from (8). The value of C_g is found from (9). Finally, we examine the result to determine if the resulting value of C_c justifies the approximations made at the outset. To illustrate this process, the following example may be helpful.

Example

Given a tube with a G_m of 5000 μmhos, an a-c plate resistance of 1 megohm, and an output capacitance of 10 μμf, given an input resistance to the next tube of 5 megohms, shunted by an input capacitance of 10 μμf. Between these tubes we wish to design an R-C coupling network for a frequency range of 20-50,000 cps, with an amplification at the limiting frequencies of 90% of maximum, or a loss in gain of 1 db at these points. Likewise, the mid-band gain is to be determined.



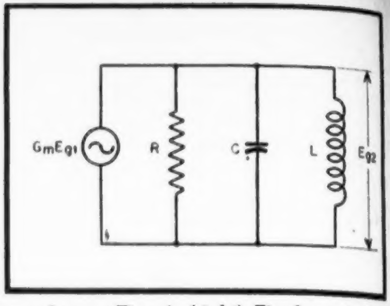


Fig. 3. (left) Redrawn circuit, in lumped impedance form. Fig. 4. (right) Final equivalent circuit consists of three shunt parameters driven by constant-current generator.

To solve the problem, we first determine the resonant frequency of the circuit. This can be computed from $f_0^2 = f_1f_2 = 20 \cdot 50{,}000 = 10^7$, or $f_0 = 3160$ cps and

$$\omega_0 = 2 \cdot 10^4$$

From (14) it is found that

$$1/LC = 4 \cdot 10^8$$

and p is given as 0.9, so that (15) can be written:

$$1-\omega_1/\omega_2 = 1-f_1/f_2 = 2\pi f_1L(1-0.81)^{1/2}/0.9R$$

yielding

$$L/R = 1.65 \cdot 10^{-2}$$

For convenience we next assume that C_c is sufficiently large that we may choose $C = C_p+C_g = 20$ μμf $= 2 \cdot 10^{-11} f$, from which L may be determined according to $1/LC = 4 \cdot 10^8$ as

$$L = \tfrac{1}{4} \cdot 10^{-8} \cdot 2 \cdot 10^{11} = 125\text{h}$$

and with this value, R may be determined from $L/R = 1.65 \cdot 10^{-2}$:

$$R = 125/1.65 \cdot 10^{-2} = 7600 \text{ ohms}$$

The maximum voltage amplification is accordingly,

$$A_0 = G_mR = 5000 \cdot 10^{-12} \cdot 7600 = 38$$

and hence the gain at mid-band is

$$G = 20 \log 38 = 21.6 \text{ db}$$

and at the limiting frequencies the gain drops to 20.6 db.

The next step is to determine the values of the coupling network. One value may be chosen from R_1, R_2, *or* C_c. When choosing R_1, it should be kept in mind that excessively high values require excessively high power-supply voltages to obtain a satisfactory operating point on the characteristics. R_2 is shunted across the input resistance of the second tube, and this latter resistance is not constant, varying continuously over the frequency range used. To minimize this influence, it is preferred to make the value of R_2 a fraction of this input resistance.

C_c should be chosen sufficiently large to justify the approximations of the computation. In theory, at least, C_c cannot be made too large, but in practice the leakage resistance is to be considered as well as the large stray capacitance to ground for the larger sizes. Increased stray capacitance of course diminishes both frequency range and mid-band gain.

To complete the design, a value may be chosen for C_c, such as 0.1 μf. With this value of C_c the value of C deviates from C_p+C_g by only one part in a thousand, so that the approximation $C = C_p+C_g$ is well justified. This is further justified from the standpoint of the approximations $1+C_p/C_c=1$ and $1+C_g/C_c = 1$ as the deviation is only one part in 10,000.

Therefore we may write

$$1/R = (1/R_p+1/R_1)+(1/R_g+1/R_2)$$

from

$$L = C_c/(1/R_p+1/R_1)(1/R_g+1/R_2)$$

we find, with $L = 125$ h and $C_c = 10^{-7} f$,

$$(1/R_p+1/R_1)(1/R_g+1/R_2) = 8 \cdot 10^{-10}$$

With $R = 7600$ ohms, it is found that

$$(1/R_p+1/R_1)+(1/R_g+1/R_2) = 1.32 \cdot 10^{-4}$$

With the given values of R_p and R_g these equations yield $R_1 = 8000$ ohms and $R_2 = 0.17$ megohms. As a matter of fact, two sets of values are found for R_1 and R_2, but with practical consideration in mind, the values noted will be most suitable.

Oscillatory Response

One more point remains to be investigated: According to *Fig. 4*, the system may respond in an oscillatory manner at its resonant frequency f_0 when a suddenly changing voltage is impressed. Should transient oscillations occur, severe distortion would of course be encountered. Under usual conditions, however, the system is sufficiently damped by R that aperiodic response is obtained.

It can be shown that L, C, and R are aperiodic if $1/R^2 \geqq 4C/L$. It follows from (9) and (10) that $4C/L$ is considerably less than $4(1/R_p+1/R_1)(1/R_g+1/R_2)$, and from (8) that $1/R^2$ is considerably greater than $[(1/R_p+1/R_1)+(1/R_g+1/R_2)]^2$. Writing $a = (1/R_p+1/R_1)$ and $b = (1/R_g+1/R_2)$, it is required for aperiodicity that $(a+b)^2 \geqq 4ab$. Since $(a+b)^2 = a^2+2ab+b^2 = 4ab+a^2-2ab+b^2 = 4ab+(a-b)^2$ it is seen that $(a+b)^2 = 4ab$ when $a = b$ and is evidently greater than $4ab$ when $a \neq b$.

Under usual conditions the system is therefore aperiodic, and the amplifier will not develop transient oscillations. This situation may be altered, however, when R_g becomes negative (which is possible if suitable conditions exist with respect to the second tube and its circuits). The negative resistance may be equal to or greater than R_2 under such conditions, but would not be frequently encountered in practice. In any event, the situation can be controlled by choosing R_2 sufficiently small.

RADIO DESIGN WORKSHEET

NO. 53 – GRAPHICS OF NEGATIVE FEEDBACK IN CASCADE

NEGATIVE FEEDBACK from output to input of a single-stage amplifier may be followed graphically on the published plate characteristics*†. In this manner the output may be plotted for a sinusoidal input of arbitrary magnitude, and a schedule analysis made of the output waveform to determine the harmonic amplitude distortion components. With a suitable complex input wave, the output waveform may likewise analyzed for intermodulation components. While the analyses have nothing to say concerning stray capacitances or inductances or imperfections of coupling devices, and are limited to waveform modifications introduced by non-linear tube characteristics, much useful information is nevertheless supplied concerning mid-band performance.

In cascade amplifiers negative feedback is often applied over two stages, as shown in *Fig. 1,* wherein a combination feedback voltage is developed from both input-stage current feedback and two-stage voltage feedback. This combination voltage is 180° out of phase with the input voltage.

To analyze this circuit and follow its operation upon the plate characteristics, it is helpful to recognize at the outset that the tube does not know to what kind of circuit it is connected, and proceeds to respond to prevailing electrode voltages in the manner depicted by the characteristics. It does not become necessary or desirable to view the characteristics and feedback potentials as operating together to simulate a fictitious tube with new values of amplification factor and plate resistance.

Instead, the analysis starts with the grid-cathode voltage of the input stage, working back to the input voltage and total feedback voltage which this grid-cathode voltage implies. This is determinable algebraically in terms of the overall gain (which varies from point to point along the load line, and is therefore considered incrementally) and leads to recalibration of the input stage characteristics in terms of input voltage.

The voltage appearing from grid to cathode of the input stage is termed e_g, and is evidently the algebraic sum of the input voltage e_i, the current-feedback voltage e_k and the potential-feedback voltage e_f. The output stage operates without modification; its amplification is the same in the presence or absence of feedback to the preceding stage. The amplification A_1 of the input stage, however, is diminished by both feedback voltages.

Current feedback develops a feedback voltage of a magnitude which is independent of the presence of the output stage. This voltage e_k is the drop across the un-bypassed cathode resistor R_k, which is directly proportional to the plate current i_1 of the input tube. Since a fraction $Fe_{o1} = e_{o1}R_k/(R_k+R_L)$ of the plate swing e_{p_1} is fed back to the grid of T_1, and $e_{o1}=A_1e_g$, $e_g=e_i - Fe_{o1}= e_i - FA_1e_g$. Solving for e_i,

$$e_i = e_g(1+FA_1)$$

Since e_g is the voltage between grid and cathode of T_1, it is also identified numerically with e_c upon the plate characteristics. Or,

$$e_i = e_c(1+FA_1)$$

The parenthetical term, then is the factor by which each value of e_c upon the characteristics is to be multiplied in order to determine e_i. These values of e_i may then be noted beside the associated values of e_c. As pointed out before, A_1 varies considerably from cut-off to the diode line (beyond which the analysis is not concerned). Therefore,

*RADIO, March, 1946

†A more rapid analysis is scheduled for publication in the near future.—*Ed.*

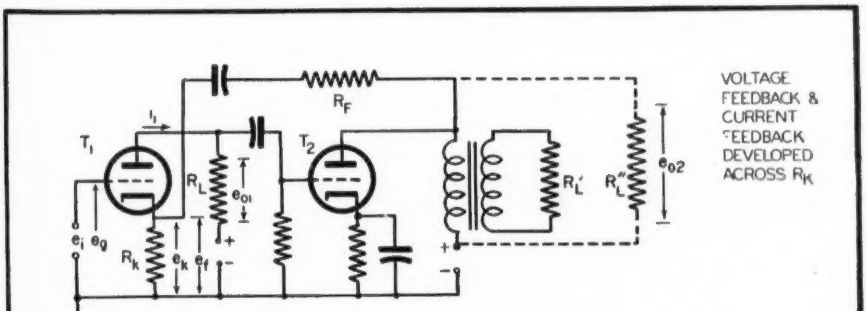


Figure 1

A_1 is determined incrementally for each successive value of e_c. In this manner, the variability of mu is taken into account.

This recalibration shows the operation of the input stage from the standpoint of current feedback, as shown in *Fig. 2*. When the characteristics of the output tube are associated with those of the modified input stage, the output voltage may be determined as also shown in *Fig. 2*. The plate swing e_{o1} of the input stage drives the grid of the output stage, and the plate swing e_{o2} constitutes the output voltage swing across R_L'', the reflected load R_L'.

The combined characteristics thus depict the operation of the two-stage circuit in the absence of voltage feedback, but with current feedback operative in the input stage. When the voltage feedback mesh is connected into the circuit, further modification of the input tube characteristics takes place. Let the fraction of e_{o2} fed back to the cathode of T_1 be termed F', whence the grid voltage of T_1 is now diminished by the amount of $F'Ge_i$ where G is the gain of the amplifier with current feedback at the input stage.

$$F' = R_k/(R_F+R_k)$$

Like A_1, G is non-linear, and is determined incrementally for successive values of e_i as shown in *Fig. 2*.

The voltage-feedback potential $F'Ge_i$ opposes the input voltage e_i, and the quantitative relationship is given by

$$e_i = e_i' - F'Ge_i$$

where e_i' is the input voltage required under conditions of combined current- and voltage-feedback. The values of e_i' are desired for the complete circuit, and hence each value of e_i is to be multiplied by the factor $(1+F'G)$.

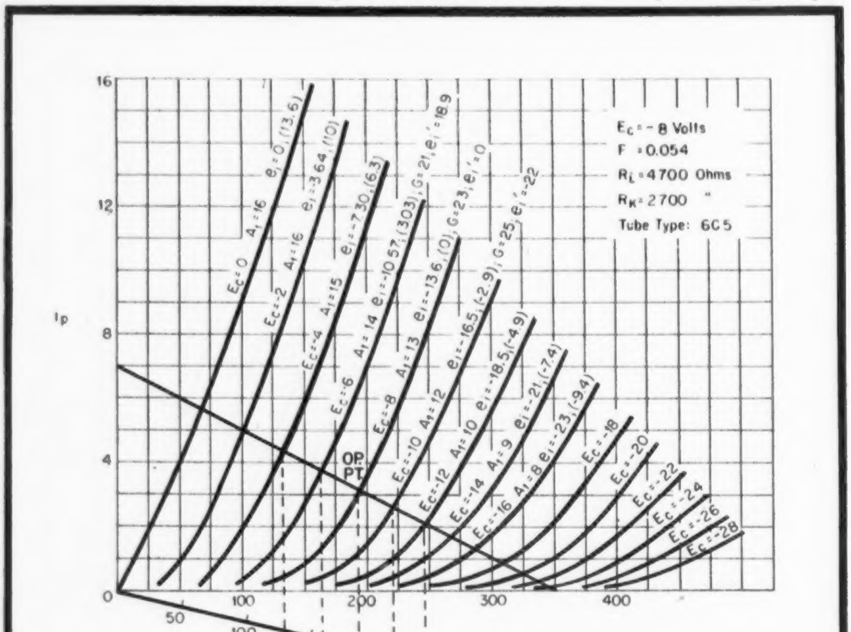


Figure 2

The final operation consists in noting these values of e_i' beside their associated values of e_i, as shown in *Fig. 2*. The operation of the amplifier may now be followed by introducing a sinusoidal input, with successive instantaneous voltages of e_i', following through the diagram to determine the corresponding output voltage swing e_{o2}, which affords the data required to plot the output waveform. A schedule analysis of this waveform yields the harmonics of the input which are generated in the circuit as a result of non-linear distortion.

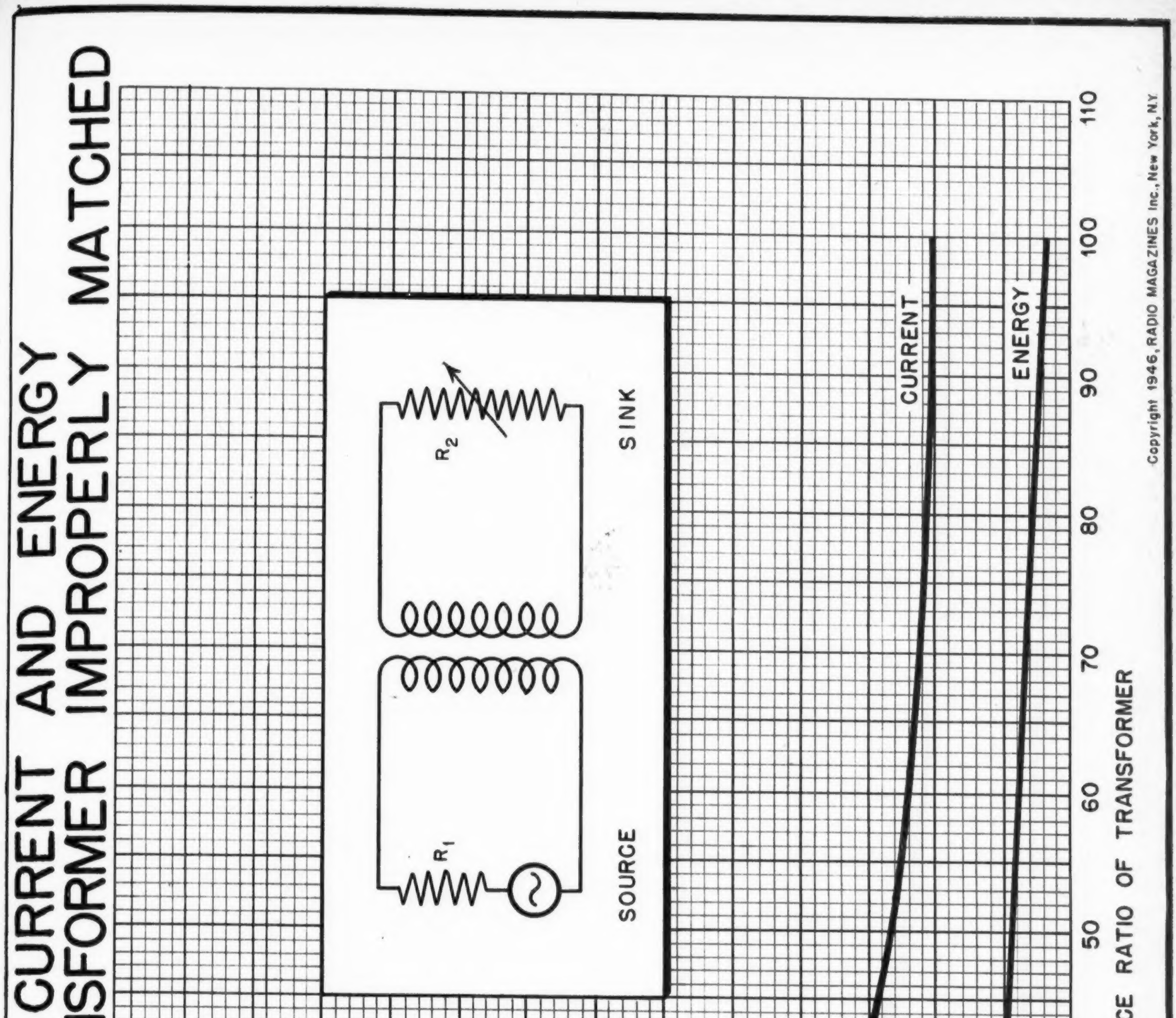
In addition, the graphical analysis serves to show the desirable regions of operation for both input and output stages, with the result that the designer may avoid regions of high distortion by inspection, without actual plotting of output waveform. To find the value of any harmonic in the output, however, calculation may be carried out on the basis of the schedule analysis.

To interpolate for integral values of e_i', a plot may be made on coordinate paper to show the relation of e_i' vs. e_p. Otherwise integral values may be located to a practical degree of precision with the aid of a pair of proportional dividers.

The gain of the circuit is of course the ratio of e_{o2}/e_i', taken incrementally as shown in *Fig. 2*. From the grid of of the first stage to the output, the overall voltage gain is approximately 31 for the parameters chosen, or expressed in terms of the input voltage, which is about 10 times greater for a given output because of feedback, the voltage gain becomes approximately 3.1 with the output-to-input feedback mesh connected. This increased amplitude of driving voltage is the price paid for the marked improvement in linearity of amplification.

An analysis of this type is particularly useful because the limits of operation may be established closely for a given circuit, without necessity of connecting up the components and making measurements. Likewise, if the driving tube is unsuited to the requirements of the output tube, this fact may likewise be determined without experimentation at the bench.

The two most time-consuming points in the analysis concern the determination of incremental amplification, and interpolation for integral voltage values which are desired. A method which reduces the time required, as well as the necessity of interpolation in this type of problem is in preparation, and will be presented in an early issue of RADIO.


DECREASE IN CURRENT AND ENERGY
DUE TO AN IDEAL TRANSFORMER IMPROPERLY MATCHED
WHEN IDEAL TRANSFORMER IS PROPERLY TERMINATED
$P_1 = \frac{E^2}{4R_2}$
OTHERWISE
$P_2 = \frac{E^2 R_2}{(R_1+R_2)^2}$
$\frac{P_1}{P_2} = \frac{(R_1+R_2)^2}{4R_2^2}$
R_1
R_2
SOURCE
SINK
CURRENT
ENERGY
DECREASE IN CURRENT OR ENERGY
0
0.2
0.4
0.6
0.8
1.0
1.2
10
20
30
40
50
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80
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IMPEDANCE RATIO OF TRANSFORMER
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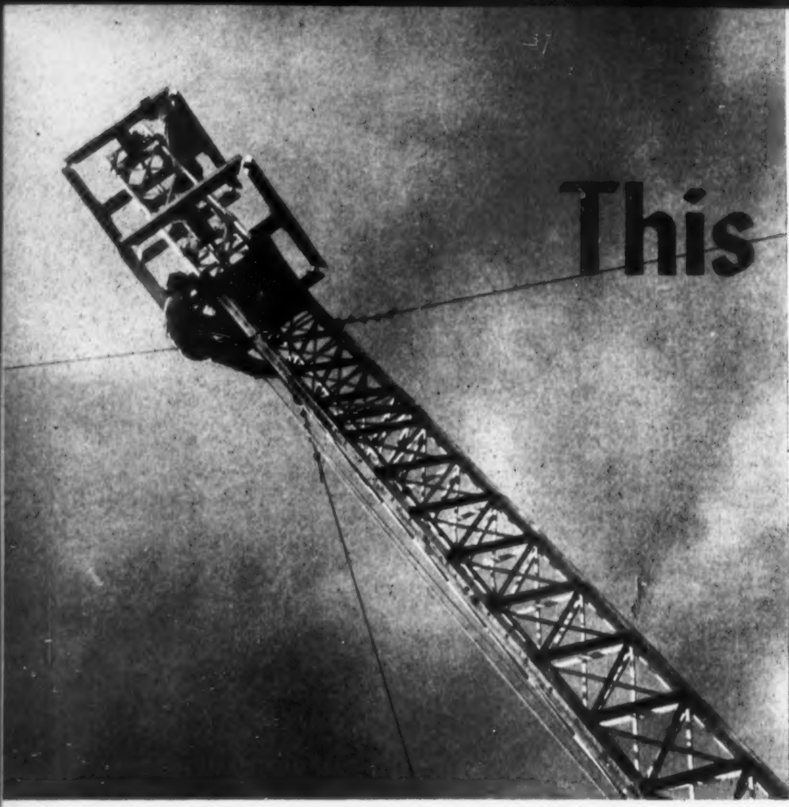


This Month

Final tuning adjustment on a two-element square-loop antenna developed by Federal Telephone & Radio Corp., Newark, N. J.

ROCKET RADIO

A compact "rocket radio" weighing less than 100 pounds and with sufficient power to send its signal 240,000 miles from the moon to the earth is technically possible, according to Dr. J. A. Hutcheson, associate director of the Westinghouse Research Laboratories, in referring to recent rocket forecasts by the Army Air Force guided-missile branch. A 100-watt transmitter capable of beaming ultrashort waves from the moon to the earth would weigh less than 50 pounds and its power supply, consisting of several automobile storage batteries, would require only an additional 50 pounds.

Continuous operation during the trip to the moon, which Mr. Hutcheson estimated at 60 hours at a speed of 4000 miles per hour, would apply too heavy a drain on the batteries. He proposes an electric clock mechanism to turn on the radio for one minute each hour. Operated in this manner, the batteries would last for several days after landing on the moon's surface.

The proximity fuse developed during the war holds the key to providing a "soft" landing for moon-rockets. As explained by Dr. Hutcheson, a tiny radio set would detect the approach of the rockets to the moon's surface. This automatically would turn on reverse rockets and turn off forward rocket power. By starting reverse power at the right moment in this application, these proximity radio sets would make possible rocket landings without damaging delicate instruments.

Dr. Hutcheson heads research in microwaves and radar as well as nuclear physics at Westinghouse. He recently returned from the second atom bomb test at Bikini where he acted as special representative for the Manhattan Project.

AUSTRALIAN TV

Introduction of monochrome television in Australia is advocated at an early date by R. C. Alsopp, consulting engineer, who cites U. S. techniques as yielding "better pictures than that provided by 16-mm home movies." He foresees stagnation and regression of u-h-f talent in that country, unless television is fostered by Parliament.

His views do not receive full acceptance, however. S. O. Jones, chief engineer of Philips Electrical Industries, has asserted that color television is essential in making a universal appeal. Mr. Jones likewise urges caution in the introduction of fm into Australia, citing a tendency in the U. S. to produce low-cost f-m receivers which "are little better than conventional a-m receivers."

GERMAN PATENTS

James E. Markham, alien property custodian, announces that the recent accord on German-owned patents extends his office's policy of licensing former German-owned patents on a non-exclusive, royalty-free basis to citizens of other countries signing the accord.

He states that the patents will continue to be available to American citizens as before. He added that the patents which are being licensed to citizens of other countries under the accord are those in which there are no lawfully acquired proprietary interests, licenses or claims held by non-Germans prior to August 1, 1946, which would conflict with the issuance of licenses.

FEDERAL PUSHES T-V DEVELOPMENT

Federal Telephone and Radio Corp. will continue its development of television equipment, including transmitters for color and high-definition black and white, studio equipment, high-gain antennas, permitted by the use of higher carrier frequencies, and the application of Pulse-Time-Modulation, leading to a number of new features in television transmission and television receivers.

Federal Laboratories designed and manufactured the color television transmitter for the Columbia Broadcasting System and is licensed by CBS to manufacture color pick-up equipment. Federal has other color television transmitters under construction, and is also prepared to supply transmitting equipment for high-definition black and white, the design principles of which have considerably progressed due to the extensive research and development on the color transmitter.

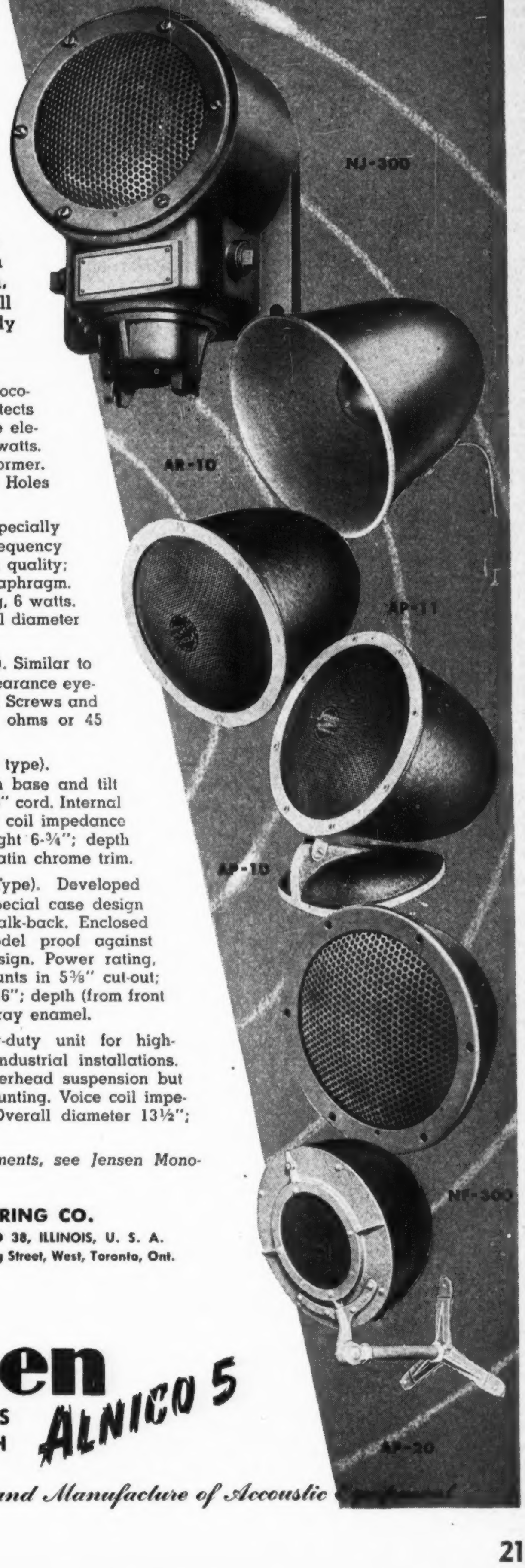
SOUTH AFRICAN BROADCASTS

The Union of South Africa expects to resume commercial broadcasting about June of 1947 after more than a decade during which it was banned. The South African radio is government-controlled like the British Broadcasting Company, which does not permit advertising on the air. But as a result of a recent study, the broadcasting board of the Union which sets radio policy for the country, has decided that by next June commercial programs can be resumed.

Jensen *Speech Master* REPRODUCERS

...for clear, crisp, intelligible Speech* Reproduction

Designed especially for speech reproduction in intercommunication and public address applications, this Speech Master family of JENSEN Reproducers, delivers clean, sharp, understandable announcements and orders. Like all JENSEN products, these Speech Masters were completely engineered to do their job efficiently and well.



MODEL NJ-300 SPEECH MASTER (Railroad Type). PM design. Widely used in railroad intercommunication in locomotives, cabooses, signal towers and yards. Rugged case protects against shock and vibration; withstands dust, smoke and the elements. Voice coil impedance 12 ohms; power rating, 10 watts. Space provided inside case for 500-ohm impedance transformer. Overall height 11-3/4"; width 6-25/32"; depth 4-13/16". Holes provided in base for mounting in any position.

MODEL AR-10 SPEECH MASTER *ALNICO 5* design. Specially constructed reflex horn increases efficiency in mid-frequency range, giving added effectiveness and "punch" to speech quality; prevents direct access of rain and snow to speaker diaphragm. Voice coil impedance, 4 ohms and 45 ohms; power rating, 6 watts. Space provided inside for ½" x ½" transformer. Overall diameter 10"; depth 8". Complete with mounting bracket.

MODEL AP-11 SPEECH MASTER (Panel mounting). Similar to AP-10 but without base. Mounts in 4-27/64" cut-out; clearance eyelets for mounting screws. Depth 4½" from front panel. Screws and drilling template included. Voice coil impedance 4 ohms or 45 ohms; power rating, 5 watts.

MODEL AP-10 SPEECH MASTER (Desk or Wall type). PM design, desk or wall mounting. Complete with base and tilt adjustment. Double dustproofed. Rubber covered 36" cord. Internal mounting bracket for ½" x ½" transformer. Voice coil impedance 4 ohms or 45 ohms; power rating, 5 watts. Height 6-¾"; depth 5⅛"; diameter 5". Finish hammered gray with satin chrome trim.

MODEL NF-300 SPEECH MASTER (Navy Type). Developed for use as a loud speaker and microphone. Special case design over-rides wind and background noises for talk-back. Enclosed case and protective screen render this model proof against weather, dust and moisture *ALNICO 5*-PM design. Power rating, 10 watts; voice coil impedance 12 ohms. Mounts in 5⅜" cut-out; six screw holes in rim. Overall diameter 6-7/16"; depth (from front of panel) 2-9/64". Finished in Munsel N4-5 gray enamel.

MODEL AP-20 SPEECH MASTER Heavy-duty unit for high-level paging and call systems in noisy industrial installations. PM design. Furnished with eyebolt for overhead suspension but available with stand for wall or table mounting. Voice coil impedance 8 ohms; power rating, 25 watts. Overall diameter 13½"; depth 9"

For full discussion of Speech requirements, see Jensen Monograph No. 4.

5 MONOGRAPHS AVAILABLE

If you haven't yet procured these five valuable technical booklets, order now—either from your dealer or direct—at 25c each.

1. Loud Speaker Frequency-Response Measurements
2. Impedance Matching and Power Distribution
3. Frequency Range in Music Reproduction
4. The Effective Reproduction of Speech
5. Horn Type Loud Speakers

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Jensen SPEAKERS WITH ALNICO 5

Specialists in Design and Manufacture of Acoustic

New Products

FEED-THRU CAPACITORS

The new hermetically-sealed, metal-cased, feed-through capacitors are now in production at the Cornell-Dubilior Electric Corp.

Current feeds through a capacitor with exceptionally low inductance, impedance and resistance. Designed specifically for attenuation of high frequency voltage components, these capacitors incorporate the better characteristics of larger, older, and more conventional types. These units also have an unusually low power-factor and remain unaffected by temperatures as high as 85° C.

Further details will be furnished upon request to Cornell-Dubilior Electric Corp., S. Plainfield, N. J.

ELECTRONIC VOLT-OHMMETER

A new electronic volt-ohmmeter, Type PM-17, has been announced by the Specialty Division of General Electric Company's Electronics Department.

Developed and designed for general service and laboratory work, the new instrument is capable of measuring audio and r-f voltages from 60 cycles to over 100 megacycles.

Featuring extremely high input impedance and simple controls, measurements may be made with the PM-17 without appreciably disturbing an existing circuit, according to division engineers.

The PM-17 weighs 15 pounds and operates from 105-120 volts, 60 cycles. An ohmmeter circuit is included for convenience in measuring high and low values of resistance.

Further information on the new electronic volt-ohmmeter is available on request to the Specialty Division of the G-E Electronics Department, Wolf Street Plant, Syracuse, N. Y.

BLOWER MOTOR FILTER

The Air Filter Corp. of Milwaukee, Wis., announces the development of the Aircor Blower Motor Filter for radio transmitters.

Unique in design and structure, this can be used either as a dry filter or as a viscous filter by merely charging it with Filmcor filter adhesive oil. Its use as a viscous filter is recommended in locations where sand and extreme dust conditions prevail — such as airports.

CuO RECTIFIERS

Copper-oxide rectifiers of new design, giving maximum output in minimum space, have been developed for battery chargers by Bradley Laboratories, Inc., 82 Meadow St., New Haven, Conn.

The new rectifiers are rated for 2, 3 and 4½ volts d-c output, with d-c current up to 1½ amperes.

Like all Bradley Coprox rectifiers, the new models have special features to combat aging. Lead wires are pre-soldered, and other types of terminals are specially designed, to prevent overheating during assembly.

I-F TRANSFORMERS

A set of new transformers for high frequency FM and AM has been placed on the market by the National Company, Inc. of Malden, Mass. All operate at 10.7 mc and can be employed unchanged on the new FM band.

Iron core tuning, used in the transformer, does not affect the 100 kc bandwidth for the IFN or 150 kc for the IFM. The discriminator output is linear over the full 150 kc output and remains symmetrical regardless of the position of the tuning cores.

Insulation is polystyrene for low losses. The transformer is 1⅜" square and stands 3⅛" above the chassis. It is available for delivery at the present time. Several variations of the above transformer have previously been manufactured by the National Company.

SOUND AMPLIFIER

Greater flexibility in sound amplifier installations for any requirement is the feature of the new line of Multiamp Add-A-Unit amplifiers recently announced by Concord Radio Corp.

From a single compact basic amplifier unit, the power output can be increased from two to nine times by simply plugging in additional, inexpensive power units. Additional output stages, to a total of six, can also be added — without additional cabinets or complicated connections. A phono-player, record changer, and output volume indicator may also be added in a matter of minutes.

CHEMICAL WIRE STRIPPER

A new chemical wire stripper, known as Cold Wire Stripper #416, was developed to remove enamel, Formvar, Formex, impregnating varnish and many other types of coatings from wire.

The wire is dipped to the length desired stripped and kept immersed 15 to 45 seconds for enameled coatings and 1 to 2 minutes for plastics and varnishes. Loose insulation is removed by drawing cloth from top to bottom of the wire.

This non-inflammable stripper is manufactured by the Ellanar Chemical Co., 308 Randolph St., Chicago 6, Ill.

NEW SPEED NUTS

A new low-priced line of heat-treated spring steel speed nuts has just been announced. This new line comprises all the sizes required to fit the ten most popular sizes of machine screws and sheet metal screws. Known as the C7000 Series, this new speed nut line has been engineered to a precision formula based upon the diameter and strength of the screw with which it is used. The new C7000 Series sells at a lower price than the threaded nut and lock washer.

Manufactured by Tinnerman Products, Inc., 2154 Fulton Road, Cleveland 13, Ohio.

TONE COMPENSATING ATTENUATOR

The Daven Company of 191 Central Ave., Newark, N. J., announces the development of a new tone compensating attenuator, Type LAC-720.

It is essentially a ladder network, designed so that the frequency characteristics follow the hearing response

RACON IS THE BEST IN SOUND EQUIPMENT

RADIAL HORN SPEAKER; a 3½' re-entrant type horn. Projects sound over 360° area. Storm-proof. Made of RACON Acoustic Material to prevent resonant effects.

PAGING HORN; extremely efficient 2' trumpet speaker for use where highly concentrated sound is required to override high noise levels. Uses P.M. unit.

RADIAL CONE SPEAKER; projects sound over 360° area. Cone speaker driven. Will blend with ceiling architecture. RACON Acoustic Material prevents resonant effects.

Leading Soundmen everywhere specify RACON Horns, Speakers and Driving Units when quoting on potential sound installation sales or rental contracts because RACONS deliver maximum output and response for size of driving unit used. There's a RACON sound reproducer for every conceivable purpose. Each affords more dependable and efficient service and they are competitively priced.

SEND FOR CATALOG
OF COMPLETE LINE

RACON ELECTRIC CO., INC. 52 EAST 19th ST. NEW YORK, N. Y.

curves of the human ear. The effect of such a response is that the bass frequencies have a smaller loss than the middle or upper registers, without rendering a false or "pumped" response.

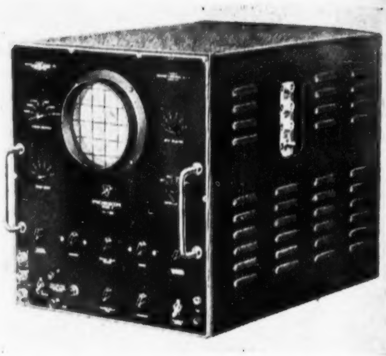
By proper external connection to lugs on the terminal board, it is possible to obtain six different attenuation vs. frequency curves with the LAC-720, varying from the "human ear type of response" to a flat frequency response. When the unit is wired for a flat frequency response it functions as a straight ladder of 2.5 db per step.

The Daven Company will welcome inquiries and comments on this unit or variations of it. Complete engineering information, including a series of six attenuation vs. frequency curves, are available on request.

SYNCHROSCOPE

A synchroscope specially designed for the visual examination of the fine structure of periodic waveforms in television, pulse time modulation, sonic depth-finders, geophysical exploration and loran equipments has been announced by the Electronics Division, Sylvania Electric Products, Inc., 500 Fifth Avenue, New York 18, N. Y.

The instrument includes a five inch cathode ray oscilloscope; trigger generator for synchronization; space for the addition of a video amplifier and r-f envelope viewer; adjustable time delay



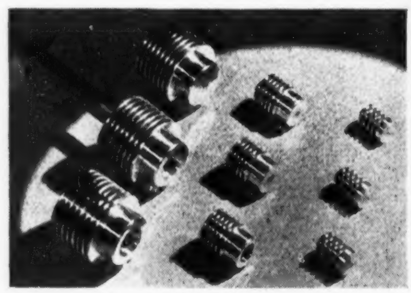
phasing circuits; and seven input connectors and selector switch for rapid viewing of separate external circuits.

Television applications include study of the shape, amplitude and duration of video pulses ranging from a fraction to several hundred microseconds. Used with a video amplifier and an r-f envelope viewer it provides a means of visual examination of r-f pulse envelopes or waveforms up to and including the microwave region.

EIMAC CONNECTORS

Eitel-McCullough, Inc., of San Bruno, Calif., announces that their HR heat dissipating connectors are now available.

These connectors are used to make electrical connections to the plate and grid terminals of Eimac and other vacuum tubes, and, at the same time, pro-



vide efficient heat transfer from the tube element and glass seal to the air. The HR connectors aid materially in keeping seal temperatures at safe value.

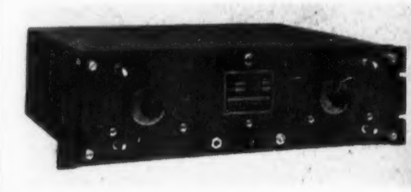
These connectors are machined from solid dural rod, and are supplied with the necessary machine screws. Complete specification and data sheets are available upon request to manufacturer.

V-H-F RECEIVER

Featuring superior performance and mechanical design, the new RV-1-B crystal controlled, fixed frequency v-h-f receiver manufactured by the Radio Receptor Company, 251 W. 15th St., New York 11, N. Y., is specifically designed to meet the rigid requirements of the airlines. Using only 140 volts plate supply to assure high component reliability, and designed into a panel only 5¼" high, the RV-1-B produces an undistorted audio output of 1 watt over a frequency range of 100 to 162 mc, with


"Help me
walk
again..."
FIGHT
INFANTILE
PARALYSIS
Join the
MARCH OF DIMES
January 15-30
THE NATIONAL FOUNDATION FOR INFANTILE PARALYSIS
FRANKLIN D. ROOSEVELT, Founder

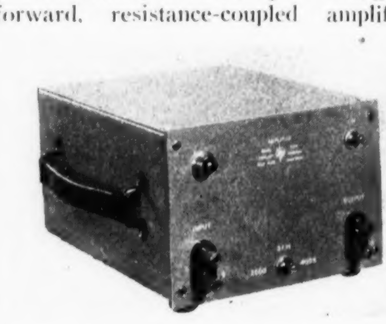
a signal-to-noise ratio of better than 2:1 for a 2 microvolt signal modulated 30%. The selectivity curve of the receiver shows it to be more than 40 kc wide at 2 times down, less than 110 kc wide at 100 times down, and less than 200 kc at 10,000 times down. The amplified a-v-c audio output changes less than 4 db for signal inputs between 10 and 100,000 microvolts. A peak noise limiter which automatically clips impulse noise, and a special "snap-action" circuit which opens the audio channel when receiving carriers of 2 microvolts or more, are other exclusive features of the RV-1-B.



For more information, write the manufacturer for Bulletin 5007A.

HEWLETT-PACKARD AMPLIFIER

The -hp- 450A Amplifier is a wideband amplifier ideal for general purpose or laboratory use. It provides unusual stability at 40 db or 20 db gain. Low phase shift is assured by a straightforward, resistance-coupled amplifier design, together with inverse feedback. Frequency response is rated within ½ db between 10 and 1,000,000 cycles. Input impedance is 1 megohm shunted by 15 mmfd. Internal impedance is less than 150 ohms over the entire range. Varying tube voltages or aging tubes have no appreciable effect on the gain or other characteristics.



MIDGET CAPACITORS

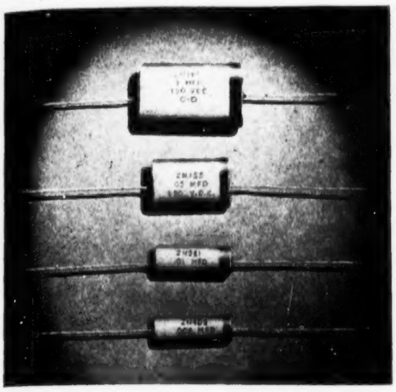
The Cornell-Dubilier Electric Corporation announces a complete line of flat midget capacitors, Type ZX, in addition to their extensive line of standard capacitors now available to manufacturers of ultra-compact electronic devices.

These new units are the smallest capacitors manufactured by C-D. Especially designed for hearing-aids and pocket-radios, they are flat and ideally adaptable for circuit applications where space is at a premium.

Type ZX midget capacitors are noninductively wound with Kraft paper

and thoroughly impregnated with halowax. The leads are securely anchored to the capacitor body. Actually, it is impossible to pull leads loose from capacitor section, or to melt compound with a soldering iron.

Standard ZN types include units from ¾″ length, ¼″ width and 3/32″ thickness to that of 1″ length, ⅝″ width



and 3/16″ thickness. The values range from .0001 mfd. to 0.1 mfd.; D.C. rated voltages from 150 volts to 600 volts.

Complete details will be furnished upon request to Cornell-Dubilier Electric Corp., South Plainfield, N. J.

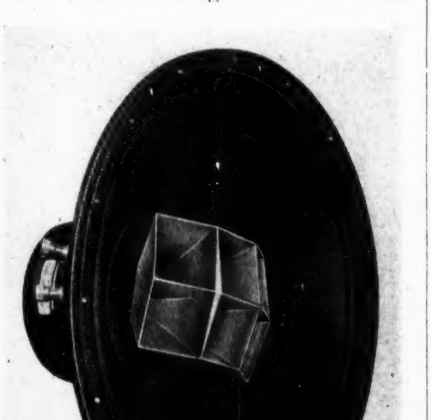
NEW DIA-CONE SPEAKER

Designed for the manufacturer whose objective is to meet the requirements of the discriminating customer who appreciates fine quality in his home radio, phonograph, music system, and FM reception, Altec Lansing announces the addition of Model 600 Dia-Cone speaker to the Altec Lansing speaker family. Others of this type are the 604 Duplex, and the popular 603 Multicell Dia-Cone, thus completing the line of speakers. This speaker, like the model 603, uses the exclusive Dia-Cone principle of reproducing low frequencies and high frequencies from separate diaphragms.

The Altec Lansing Model 600 Dia-Cone speaker is mounted in a 12″ frame. It uses an Alnico V permanent magnet and a 3″ wound aluminum voice coil to which is mounted a domed aluminum alloy metal diaphragm and a seamless moulded cone. The seamless moulded cone vibrates as a piston with the voice coil to reproduce all lower frequencies up to approximately 2,000 cycles.

A moulded paper cone cannot faithfully reproduce frequencies above approximately 2,000 cycles since it begins to break up in that frequency range. As the cone begins to break up, the domed metal diaphragm, with its high mass stiffness and high transmission speed, continues to operate as a piston with the voice coil resulting in a true reproduction of the higher frequencies. The shape of the metal diaphragm provides a means of radiating the high frequencies over a wide area with a smooth distribution pattern eliminating the high frequency beam. The light mass of the aluminum diaphragm and edge wound voice coil wire allows faithful reproduction of frequencies much higher than is produced by the ordinary loudspeaker unit.

The large Alnico V permanent magnet, the careful design of the magnetic circuit to close tolerances, and the use of an edge wound voice coil result in



a very high efficiency that will deliver 89 db. (Ref. 10^{-16} dynes per sq. cm.) at 5′ with an input of .1 watt.

NEW HOOK-UP WIRE

A thermoplastic insulated radio hook-up wire, tested to underwriters' standards, is now in volume manufacture by Federal Tel. and Radio Corp., Newark, N. J. The extreme flexibility of Federal's Intelin hook-up wire, its small outside diameter, and permanent colors facilitate quick, accurate assembly and easy servicing.

It is stated that this wire is not affected by oxidation and changes in temperature, will not crack or become brittle, and will remain operative under all conditions of humidity. The tough, abrasion resistant insulation reduces the possibility of accidental damage. Because the thermoplastic insulation is highly resistant to flame, equipment wired with Intelin is free from fire hazard.

The wire is high in dielectric and tensile strength. Short time tests show a dielectric strength of 800 volts per mil with a 0.020 inch wall thickness; thirty day tests at 90°C show a tensile strength of 2100-2250 pounds per square inch.

The free stripping feature is an aid to quick servicing, the conductor is left clean and bright for instant tightly soldered connections. Available in solid or stranded types, the wire ranges in size from 24 to 14 for high or low voltage needs in radio, electronics, appliances, and communications and comes in 14 brilliant colors.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACTS OF CONGRESS OF AUGUST 24, 1912, AND MARCH 3, 1933

of RADIO, published monthly at Orange, Connecticut, for October 1, 1945.

State of New York }
County of New York } ss.:

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Sanford R. Cowan, who, having been duly sworn according to law, deposes and says that he is the Publisher of RADIO, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, to wit:

1. That the names and addresses of the publisher, editor, managing editor and business manager are: Publisher, Sanford R. Cowan, 1620 Ocean Ave., Brooklyn 30, N. Y.; Editor, John H. Potts, 154-18 35th Ave., Flushing, N. Y.; Managing Editor, None; Business Manager, S. R. Cowan, 1620 Ocean Ave., Brooklyn 30, N. Y.

2. That the owners are: Radio Magazines, Inc., 342 Madison Ave., New York 17, N. Y.; John H. Potts, 154-18 35th Ave., Flushing, N. Y.; and Sanford R. Cowan, 1620 Ocean Ave., Brooklyn 30, N. Y.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities, are: None

4. That the two paragraphs next above, giving the names of the owners, stockholders and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock, and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

(Signed) SANFORD R. COWAN, Publisher.

Sworn to and subscribed before me, this 18th day of September, 1946.

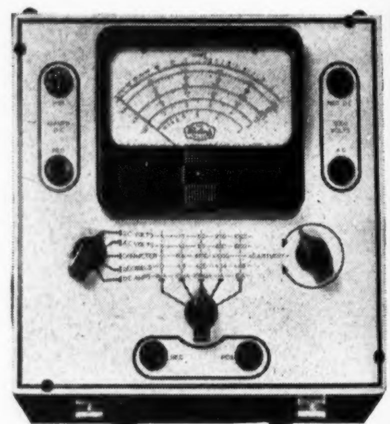
(Seal.) SYLVESTER J. VITKANSAS, Notary Public.

Kings Co. Clk's No. 12, Reg. No. 64-V-8; N. Y. Co. Clk's No. 48, Reg. No. 90-V-8; Bronx Co. Clk's No. 1, Reg. No. 28-V-8. Commission expires March 30, 1948.

ELECTRONIC TESTER

A new portable, graphic type of instrument for servicing radio and other electronic equipment has been announced by The Sterling Manufacturing Co. of Cleveland.

This tester, according to the makers, simplifies selection of desired function and



range. In operation, the graphic tester is read, as the term implies, quickly, easily and accurately, like a graph. Desired function and range are selected by means of two switches of the graphic selector system. The left, or function switch, is set for the *type* of measurement desired. The lower, or range switch, is set for the *range* of the type of measurement indicated by the function switch. The adjustment knob at the right is used to set the meter pointer to zero ohms for the three ohmmeter ranges . . . service men can then find the correct reading quickly and accurately on the large meter.

MULTI-WIRE CONNECTORS

A new multi-wire connector announced by Alden Products Co., 117 North Main St., Brockton, Mass., features an unthreaded lock which engages by means of a slotted locking ring working against a rubber gasket. Numerous other new features are set forth in a bulletin which will be supplied on request.

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Personal Mention

Roy Dallv

★ Roy Dally, contributor of numerous articles to RADIO on pickup design and

Roy Dally

related topics, has been appointed chief engineer in charge of phonograph and pickup design by Electrovox Co., Inc.

Lynn Brendel

★ Lynn Brendel, systems engineer with Hallicrafters Co. since October 1945,

Lynn Brendel

has been promoted to the post of general service manager. Brendel assisted in development of the first auto radios.

Edward E. Schultz, Jr.

★ Cook Electric Company, Chicago, announces the addition of Edward E. Schultz to the engineering staff of its new division, Cook Research Laboratories, devoted to studies of major physical problems involving industrial processing and instrumentation. Mr. Schultz will assist in directing research on transient motion, measuring instruments, flow controls, pressure switches, and aircraft controls involving electronic, hydraulic and mechanical systems.

A graduate of Northwestern University's School of Electrical Engineering, Mr. Schultz brings a broad background of experience to Cook Research Laboratories. He has been associated with Joseph T. Ryerson Steel Company, the National Broadcasting Company, and

ADDRESS CHANGES—

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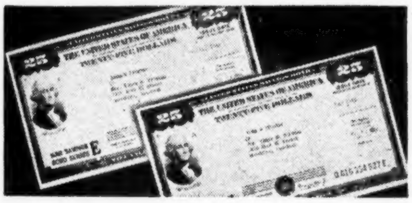
America finds a new, easy way to save

Out of the war has come one blessing—a lesson in thrift for millions of those who never before had learned to save.

Enrolled under the Payroll Savings Plan in thousands of factories, offices, and stores, over 27 million American wage earners were purchasing "E" Bonds alone at the rate of about 6 billion dollars worth a year by the time V-J Day arrived.

With War Bond Savings automatically deducted from their wages every week, thrift was "painless" to these wage earners. At the end of the war, many who never before had bank accounts could scarcely believe the savings they held.

The moral was plain to most. Here was a new, easy way to save; one as well suited to the future as to the past. Result: Today, millions of Americans are continuing to buy, through their Payroll Savings Plan, not War Bonds, but their peacetime equivalent—*U. S. Savings Bonds.*



From war to peace! War Bonds are now known as U. S. Savings Bonds, bring the same high return—$25 for every $18.75 at maturity.

Out of pay—into nest eggs! A wage earner can choose his own figure, have it deducted regularly from earnings under Payroll Savings Plan.

New homes to own! Thousands of new homes, like this, will be partially paid for through Bonds wisely accumulated during the next five to ten years.

Keeping cost of living in check! Buying only needed plentiful goods and saving the money which would bid up prices of scarce goods keeps your cost of living from rising. Save *automatically—regularly.*

Weekly Savings	SAVINGS AND INTEREST ACCUMULATED	
	In 1 Year	In 10 Years
$ 3.75	$195.00	$2,163.45
6.25	325.00	3,607.54
7.50	390.00	4,329.02
9.38	487.76	5,416.97
12.50	650.00	7,217.20
15.00	780.00	8,660.42
18.75	975.00	10,828.74

Savings chart. Plan above shows how even modest weekly savings can grow into big figures. Moral: Join your Payroll Savings Plan next payday.

SAVE THE EASY WAY...
BUY YOUR BONDS
THROUGH PAYROLL SAVINGS

Contributed by this magazine in co-operation with the Magazine Publishers of America as a public service.

A Public Service Project — The Advertising Council

during the war was chief engineer of Press Wireless and Radio Craftsmen, Inc.

L. E. Bessemer

★ L. E. Bessemer, design engineer of Collins Radio Co., has been appointed

L. E. Bessemer

general manager of the manufacturing division. His initial job at Collins was wireman on a production line.

Cornish Representative

Cornish Wire Co., New York City, manufacturers of Industrial and Communication Wire, announces the appointment of Henry L. Mills to represent their complete line.

MODULATING METHODS

[*from page* 11]

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ADVERTISING INDEX